

# JOURNAL

## OF THE

# AMERICAN WATER WORKS ASSOCIATION

VOL. 30

SEPTEMBER, 1938

No. 9

### CONTENTS

Water Isn't H <sub>2</sub> O. By A. M. Buswell.....	1433
Corrosion Prevention by Cathodic Protection. By Starr Thayer.....	1442
Discussion by Robert J. Kuhn.....	1448
Electrolysis Troubles. By John B. Dean and D. D. Gross.....	1451
Typhoid in the Large Cities of the United States in 1937.....	1456
Recent Experiences in Sterilization of Distribution Systems. By B. A. Poole.....	1471
Reinforced Concrete Pressure Pipe for Montreal Water Works. By Charles J. Des Baillels.....	1478
Discussion by F. F. Longley.....	1489
A Unique Iron Removal Plant. By Peter Ley.....	1493
Discussion by William I. Klein.....	1502
Discussion by Frank E. Hale.....	1503
Pressure Filters for Iron Removal. By R. S. Charles, Jr.....	1507
Automatic Valves. By William F. End.....	1514
The Use of Clay in Coagulation and Taste and Odor Control. By Paul Weir.....	1528
Discussion by Rennie I. Dodd.....	1538
The Merit System of Dallas, Texas Applied to Water Works Employees. By J. B. Winder.....	1540
Water Softening at Minneapolis. By J. A. Jensen.....	1547
Discussion by Charles H. Spaulding.....	1563
Discussion by Malcolm Pirnie.....	1565
Abstracts.....	1569
Constitution and By-Laws of the A.W.W.A. (Supplement)	v
Coming Meetings.....	vi
Additions to Membership List.....	i
News of the Field.....	

*All correspondence relating to the publication of papers should be addressed to*

**Harry E. Jordan, Secretary**

→ 22 East 40th St., New York ←

Subscription Price to Members—\$7.00

Additional single copies, to members—50 cents

Single copies to non-members—75 cents



## When Accessibility is *Important*...



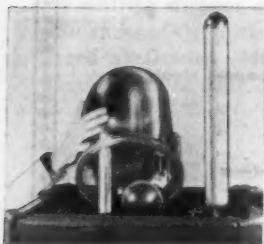
**M**AYBE you've never been in the same predicament as our young friend above, but, if you've ever operated a piece of mechanical apparatus, you've doubtless felt just as helpless while trying to make some adjustment or repair.

With a W&T Visible Vacuum Chlorinator you don't have to see around corners or tie your back in kinks to reach some hidden part. It's all out in the open, with operation as visible as the view of the street from your own front porch and every part easily accessible without muscular contortion or mental strain. Lift the bell jar and the complete mechanism is ready to your hand; remove the full height side panels and all of the connecting pipe and hose lines are within easy reach.

Accessibility is important for the operator's peace of mind. It's important, too, to the man who pays the bills, for minor adjustments made when needed forestall many an expensive repair. That is one of the reasons why W&T Visible Vacuum Chlorinators have been and continue to be the world's most popular and widely used units for dependable, accurate and economical control of the chlorination process.

Write today for technical publications describing W&T Visible Vacuum Chlorinators.

*"The Only Safe Water is a Sterilized Water"*



## WALLACE & TIERNAN CO., Inc.

Manufacturers of Chlorine and  
Ammonia Control Apparatus



NEWARK, NEW JERSEY  
Branches in Principal Cities

CHLORINATORS FOR WATER WORKS • SEWAGE PLANTS • SWIMMING POOLS • INDUSTRIAL PLANTS

# JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION

COPYRIGHT, 1938, BY THE AMERICAN WATER WORKS ASSOCIATION

Reproduction of the contents, either as a whole or in part, is forbidden, unless specific permission has been obtained from the Editor of this JOURNAL. The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

Vol. 30

September, 1938

No. 9

## WATER ISN'T $H_2O$

By A. M. BUSWELL

Much has been written on the subject of the "impurities" found in water as it is obtained in nature from wells, rivers, and lakes. And while great progress has been made in devising ways and means for removing or altering these impurities so that the treated product will be suitable for human consumption and industrial use, we are well aware that much, very much, remains to be done along that line.

But we find it interesting occasionally to turn our attention to the consideration of the substance "water" itself. This view point was first suggested to us by the late Professor Charles Frederick Chandler of Columbia University. Professor Chandler always loved to shake people out of their ruts. One day he asked me what I was doing and I replied, "Analyzing a sample of water." He glanced over my notes and then said, "No, you are not; you are just testing a sample of water. Your determinations won't add up to one hundred per cent; they won't add up to one per cent. Don't forget that what flows down from Croton reservoir to New York is 99.9947 per cent *water*."

If we turn our attention to what is known about the "water" in water we find that physicists and physical chemists have been giving

---

A contributed résumé of research by A. M. Buswell, Chief, State Water Survey Div., Urbana, Illinois.

a lot of attention to this subject, especially in the last few years. Chemical Abstracts for 1936 alone included two thousand articles on the chemical and physical properties of water. Probably the most important recent chemical discovery is that of heavy hydrogen for which Dr. Urey of Columbia University received the Nobel prize in 1934 (1) (2). Dr. Urey found that the purest water that could be prepared in the laboratory contained besides hydrogen and oxygen another substance like hydrogen but with an atomic weight of two, or twice that of hydrogen. This substance, which is now called *deuterium* (D), combines with oxygen to form the compound  $D_2O$ . This deuterium oxide has a specific gravity of 1.1 and is known as "heavy water." It is also known that there are three

TABLE 1  
Molecules and ions in "purest" water

FORMULA	MOL. WT.	FORMULA	MOL. WT.	FORMULA	MOL. WT.
$H_2O$	18	$H_2O^{17}$	19	$H_2O^{18}$	20
HDO	19	HDO <sup>17</sup>	20	HDO <sup>18</sup>	21
$D_2O$	20*	$D_2O^{17}$	21	$D_2O^{18}$	22
HTO	20	HTO <sup>17</sup>	21	HTO <sup>18</sup>	22
DTO	21	DTO <sup>17</sup>	22	DTO <sup>18</sup>	23
$T_2O$	22	$T_2O^{17}$	23	$T_2O^{18}$	24

\* Heavy water.

Ions

$H^+$	$OH^-$	$O^{17}H^-$	$O^{18}H^-$	$T^+$	$OT^-$	$O^{17}T^-$	$O^{18}T^-$
$D^+$	$OD^-$	$O^{17}D^-$	$O^{18}D^-$	$-O^-$	$^{17}O^-$	$^{18}O^-$	

kinds of oxygen which differ principally in their atomic weight, namely, ordinary oxygen with atomic weight of sixteen ( $O^{16}$ ), oxygen with atomic weight of seventeen ( $O^{17}$ ) (3), and oxygen with atomic weight of eighteen ( $O^{18}$ ). More recently a third hydrogen-like substance—*tritium* (T) (4) has been recognized. That makes six elements or isotopes, as they are called, now found in the purest water available in the ordinary laboratory. "Water" therefore instead of being  $H_2O$  contains the imposing list of substances, thirty-three in all, which are shown in table 1.

Of these substances the deuterium or D compounds ( $D_2O$ ) are found present to the extent of about 200 parts per million, and the  $O^{18}$  compounds perhaps as high as 1,000 parts per million. Since  $O^{18}$  is very similar to ordinary oxygen ( $O^{16}$ ), it is difficult to separate

and study and is not regarded as particularly important at present. The O<sup>17</sup> and the tritium (T) compounds are present in exceedingly small amounts. For the present we may dismiss the O<sup>17</sup>, O<sup>18</sup>, and T forms of water from further consideration. Since D<sub>2</sub>O differs both chemically and physically from H<sub>2</sub>O and is found in appreciable amounts, it is attracting wide interest.

Heavy water boils at a little higher temperature than H<sub>2</sub>O. This property permits its concentration by fractional distillation. The

TABLE 2  
Physical properties\*

	H <sub>2</sub> O	D <sub>2</sub> O
Density <sup>25</sup> †.....	1.0000	1.0790 ± .00005
Temp. Max. Density.....	4.0°C.	11.6°C.
Molar vol. at Temp. of Max. Density.....	18.015 cc.	18.140 cc.
Lattice Constants of Ice.....	a 4.525 Å°	4.505 Å°
	b 7.39 Å°	7.36 Å°
Mol. Vol. of the Ices at 0°C.....	19.65 cc.	19.32 cc.
Dielectric Constants.....	81.5	80.7
Surface Tension.....	72.75 dyne/cm	67.8 dyne/cm
Viscosity (millipoises):		
10°C.....	13.10	16.85
20°C.....	10.09	12.60
30°C.....	8.00	9.72
Ref. Index M <sub>D</sub> <sup>20</sup> .....	1.33300	1.32828
Melting Point.....	0.0	3.802°C.
Boiling Point.....	100.0°C.	101.42°C.
Heat of Fusion.....	1,436 cal.	1,510 cal.
Heat of Vaporization.....	10,484 cal.	10,743 cal.
K <sub>ioniz</sub> (Ionization Constant).....	1.04 × 10 <sup>-14</sup>	0.33 × 10 <sup>-14</sup>

\* Most of data from H. C. Urey and G. K. Teal. Rev. Mod. Physics, 7: 34-94(1935).

† When O<sup>18</sup>:O<sup>16</sup> ratio is normal, normality being  $\left\{ \begin{matrix} 514 \pm 13:1 \\ \text{O}_{16} : \text{O}_{18} \end{matrix} \right\}$ .

still columns required are thirty to forty feet in height and the process of concentration is very slow. Since deuterium ions require a higher voltage for their electrolytic separation than do hydrogen ions, the solution used for the electrolytic production of hydrogen becomes enriched in D<sub>2</sub>O. This is the basis of the process by which most of the D<sub>2</sub>O is produced at present.

The physiological properties of D<sub>2</sub>O are surprising (5). Heavy water appears to be entirely inert and useless as far as its effect on

plants and animals has been studied. Seeds will not sprout in  $D_2O$  and rats given only  $D_2O$  to drink will die of thirst. There are no poisonous effects of  $D_2O$  since if  $H_2O$  is given soon enough rats which have had only  $D_2O$  will recover and will show no ill after-effects.

The present importance of heavy water is its use in theoretical research in chemistry, especially in organic and biochemistry. If compounds containing active hydrogen are treated with  $D_2O$ , deuterium will replace the hydrogen and the compound will show certain alterations in properties.

It is interesting to find that the amount of  $D_2O$  in natural water appears to be the same whether the water comes from an alpine

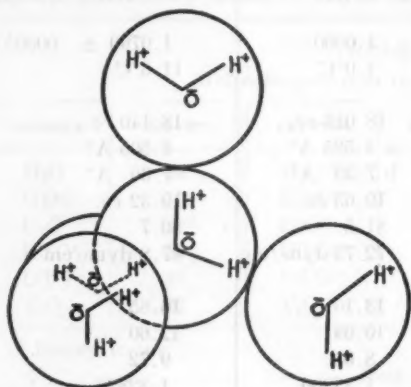


FIG. 1. Tetrahedral coördination of water molecules. The four molecules surrounding one water molecule are shown. Of these, two are in the plane of the paper, one above and one below it. (After Bernal and Fowler)

glacier or the bottom of the ocean and whether it is formed by destructive distillation of willow wood or mahogany.

Heavy water ( $D_2O$ ) has been extensively studied since its discovery and its physical properties are fairly well known. Table 2 gives a comparative list of the characteristics of  $H_2O$  and  $D_2O$  in more detail.

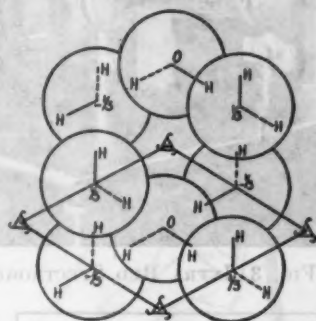
#### STRUCTURE OF LIQUID WATER

Our notions of the structure of liquid water must also be revised as well as our ideas of its composition. This is the result of our progress in understanding valence. A generation ago chemical valence was without any real explanation. Different elements were known to be capable of combining chemically in certain ratios, but no one knew why, and the student was forced to memorize the valences of the elements with which he had to work. Oxygen had a valence of two and hydrogen one and they combined to form  $H-O-H$

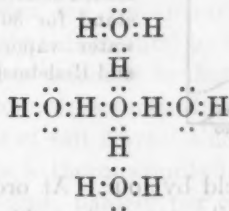
which was a saturated compound as far as its valences went and not capable of further chemical combination. We now know that chemical valence is dependent on the number of electrons which compose the outer shells of the various atoms, a pair of electrons comprising one bond or valence. When the central atom of a compound molecule has eight electrons about it,\* it is a very stable substance.

Water fulfills this condition. Each hydrogen atom has one electron and oxygen has six. H<sub>2</sub>O then is a stable compound with an eight electron shell around the oxygen.  $H : \ddot{O} : H$ . It is further known (6) that the hydrogen may serve to hold two atoms together

FIG. 2. "Quartz" water structure. The molecules are in three layers: — (1)c, 0, (1)c from the base of the cell. The OH directions pointing upwards are shown —H. The OH directions pointing downward are shown -----H. The central atom shows the distorted tetrahedral coördination. (After Bernal and Fowler)



particularly where those atoms are oxygen or nitrogen. This is a special type of valence and is coming to be called the "hydrogen bond." It is possible for water molecules to be combined into large groups by means of these hydrogen bonds somewhat as follows:



In space the water molecule is considered as a tetrahedron and the arrangement in perspective would be similar to figs. 1 and 2.

\* For further discussion and references to the original literature, see "Chemistry of Water & Sewage Treatment" (Buswell), A. C. S. Monograph 38, p. 60.

These figures are taken from a paper by Bernal and Fowler (7) and represent the actual arrangement of molecules in liquid water as shown by X-ray studies. It may be noted that this arrangement is the same as that of  $\text{SiO}_2$  molecules in quartz.

So liquid water is to be pictured as a flexible network of molecules, each one bound or held at any instant by four other molecules and

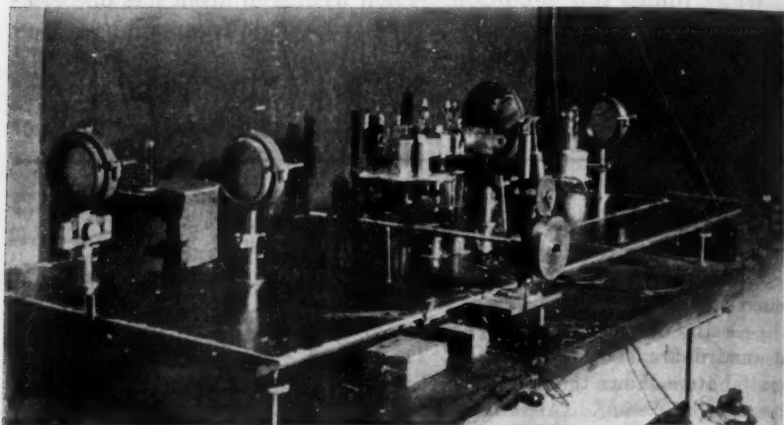


FIG. 3. INFRA RED SPECTROGRAPH. (PHOTO BY ARTHUR A. BUSWELL)

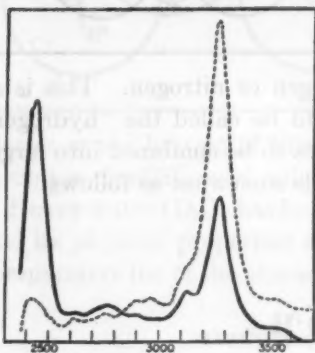


FIG. 4. Absorption curves for a dilute solution of o-nitrophenol in carbon tetrachloride. The solid line represents o-nitrophenol which has been treated with pure deuterium oxide. The dotted line represents the absorption curve obtained after the solution was allowed to stand for 30 minutes in contact with water vapor. (After Buswell, Deitz, and Rodebush)

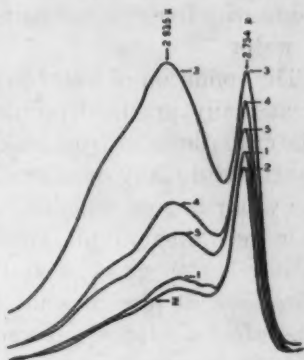
each of these in turn held by four. At ordinary temperature this results in a structure similar to quartz. At a lower temperature the arrangement becomes that found in the mineral tridymite which is also the structure found in ice. This structure is somewhat more open than the quartz-like structure and explains the change of water density with temperature. At the critical temperature the water

molecules have a close packed arrangement. Liquid water then consists of molecules held to one another by hydrogen bonds and arranged in three different geometrical patterns, Water I, trydinite or ice-like; Water II, quartz-like, and Water III, "close packed."

#### SPECTROSCOPY

To round out the picture of modern water chemistry, a brief discussion of the spectroscopy of water is in order. We call water colorless because it transmits that part of the sun's radiation which our eyes can detect ( $0.4 \mu$  to  $0.8 \mu$ ) without absorption. If our eyes were able to detect the longer or infra red radiations we would probably find water to be very opaque, about like india ink.

FIG. 5. Montmorillonite: curve 1, film dried at  $100^\circ$  for thirty-six hours; curve 2, film dried at  $100^\circ$  for additional six hours; curve 3, air saturated with water vapor at  $26^\circ$  passed through cell for five hours; curve 4, film dried at  $110^\circ$  for six hours; curve 5, film dried at  $110^\circ$  for additional twenty-four hours. (After Buswell, Krebs, and Rodebush)



Salt crystals and carbon tetrachloride would still be colorless, but glass would be black or dark grey.

Colorimetry has always been a useful method in chemistry, and the development of infra red colorimetry or spectrophotometry makes it possible to apply this method to the study of water. The optical system is similar in principle to that used in the visible. Its construction differs in that mirrors must be used instead of lenses and the prism must be made of salt crystal since glass is opaque in this region. The detector is a thermocouple instead of the eye. The data obtained are the same, namely per cent absorption vs. wave length.

The use of the infra red spectrograph for studying the state of water in various compounds especially where the valence was obscure was first suggested by Coblenz in 1911 (8). He found that the water of hydration of certain minerals showed absorption peaks at the

approximate wave lengths of 1.5, 2.0, 3.0, 4.75, and  $6\mu$ . He also noted similar absorption especially at  $3\mu$  for gelatin which contained some moisture. This he interpreted as indicating some sort of combination between the water and the gelatin.

Little progress was made in the clarification of many such situations until the development of our modern theory of valence a decade later. One of the corollaries to this theory of valence was put forward in the paper by Latimer and Rodebush (6) which proposed the hydrogen bond as an explanation of the valence in certain compounds (e.g., ammonium hydroxide,  $\text{H}_3\text{N} : \text{H} : \text{OH}$ ). This suggestion appeared to offer a plausible explanation of the way in which many substances combine with water to form gels since such substances (gelatin, agar, starch, silica, etc.) have oxygen or nitrogen atoms with free electron pairs which could share one of the hydrogens of water.

The condition of water in colloid systems, gels, etc., is related to a great many practical problems such as the drying of sludges, the winter hardness or frost resistance of wheat, the drouth resistance of insects, and many questions in physiology. It appears that part of the water in such colloids is combined or "bound" and part is free or in the ordinary liquid condition. Many attempts have been made to develop an experimental method for determining this "bound" water and at present some ten different tests are used by different laboratories. Infra red spectroscopy seems to offer the greatest promise because it measures the valence bond by which the water is "bound."

The apparatus used in our laboratory in collaboration with Professor W. H. Rodebush (9, 10) is shown in fig. 3. Two curves will show some results of this sort of work. Fig. 4 shows the effect of substituting deuterium for hydrogen in the OH group of ortho nitro phenol ( $\text{C}_6\text{H}_4\text{NO}_2\text{OH}$ ). The effect of the heavier deuterium atom is to cause the absorption band to shift to a smaller wave number or a longer wave length. When H replaces the D atoms the original absorption band reappears. Such reactions are used to identify spectral bands.

The second example, fig. 5, shows how the absorption of water by colloids can be studied. The zeolites, which are important both in water softening and as constituents of soils, are known to hold water in at least three different forms (11). The curve shown here for the infra red absorption of a zeolite film containing varying amounts of

water indicates that two forms of water are present and also shows how these two forms combine with the oxides which compose the anhydrous material. The OH of water or other compounds has a definite absorption at about  $2.75\mu$ . But if the OH is "hydrogen bonded" the absorption is at  $3\mu$ . The curve shows that water first combines with the oxides in the clay, forming hydroxides. This is followed by combination with water by means of hydrogen bonds as shown by the rise of the  $3\mu$  band.

When similar curves are run on agar and gelatin, we find no evidence of OH. At other regions of the spectrum we find further evidence on the combination of water in gels. This work is in active progress and promises to throw a great deal of light on many of the problems met with in water chemistry.

#### REFERENCES

1. UREY, H. C., BRICKWEDDE, F. G., and MURPHY, G. M. *Phys. Rev.*, **39**: 164, 864(1932); **40**: 1(1932).
2. UREY, H. C. and TEAL, G. K. *Rev. Mod. Physics*, **7**: 34-94(1935).
3. GIAUQUE, W. F., and JOHNSTON, H. L. *J. Am. Chem. Soc.*, **51**: 3528 (1929).
4. OLIPHANT, HARTECH, and RUTHERFORD. *Nature* **133**: 413(1934); *Proc. Roy. Soc. A*-**144**: 692(1934).
5. A Review. *Yale J. Biol. Med.*, **9**: 551-65(1937).
6. LATIMER and RODEBUSH, W. H. *J. Am. Chem. Soc.*, **42**: 1419(1920).
7. BERNAL and FOWLER. *Trans. Farad. Soc.*, **29**: 1049(1933).
8. COBLENTZ, W. W. *J. Franklin Inst.*, **172**: 309(1911).
9. BUSWELL, A. M., DIETZ, VICTOR and RODEBUSH, W. H. *J. of Chem. Physics*, **5**: 7; 501-504(1937).
10. BUSWELL, A. M., KREBS, KARL and RODEBUSH, W. H. *J. Am. Chem. Soc.*, **59**: 2603-2605(1937).
11. HOFMANN, U., ENDELL, K. and WILM, D. *Z. Krist.*, **86**: 340-348(1933).

## CORROSION PREVENTION BY CATHODIC PROTECTION

BY STARR THAYER

Many papers and articles have been published on the subject of electrically protecting buried pipe lines against corrosion. This paper will attempt to summarize the development of cathodic protection from the beginning. It is well to state here that this paper will deal only with corrosion of buried or submerged metals. Corrosion of metals in the air or in fumes is treated in a different manner.

Before we can intelligently discuss this subject of protection we should understand the causes of corrosion. For convenience we may divide the causes of loss of metal into three classes: electrolysis, long line currents, and soil corrosion.

Electrolysis is generally referred to as the loss of metal caused by man-made stray currents. This condition would exist in cities having street railways, for instance. The remedy here, of course, is to install the proper drain wires to carry these currents back to their source instead of allowing them to pass off into the soil.

As regards long line currents, it has been found that, when long pipe lines are built, currents will often enter the pipe at some places and discharge into the soil at others. These currents are always relatively small. It is not probable that these currents in themselves cause much trouble. Probably the other causes of corrosion will be so much more severe that the effects of the long line currents will not be measurable.

Soil corrosion is the most common and most destructive of the agencies which attack buried metal. This corrosion is primarily due to the composition of the surrounding soils. The relation of corrosion to soil analysis is in itself a large subject for discussion. Briefly, the more common factors that make a soil corrosive are acidity, electrical conductivity, and oxygen, moisture, and salt content. These are but a few of the causes. However, it is not the purpose of this paper to discuss the causes of corrosion, but rather to study means of stopping it.

---

A paper presented at the New Orleans convention April 28, 1938, by Starr Thayer, Consulting Electrolysis Engineer, Houston, Texas.

It is common practice now in building new lines to coat the pipe with a protective material. If this material is properly applied and is properly selected the losses due to corrosion may be almost, if not completely, eliminated. It is the existing lines, or lines laid in the past, that are the chief concern of the operator. To remove and repair or replace these lines involves very expensive operations, and it is with these lines that the use of electrical protection is most justifiable.

#### CATHODIC PROTECTION

It has been proved that, regardless of the cause of the corrosion on the pipe, the action is the same. Currents are generated in the pipe itself. These currents flow in the pipe wall to areas where they discharge into the soil. This is illustrated in fig. 1.

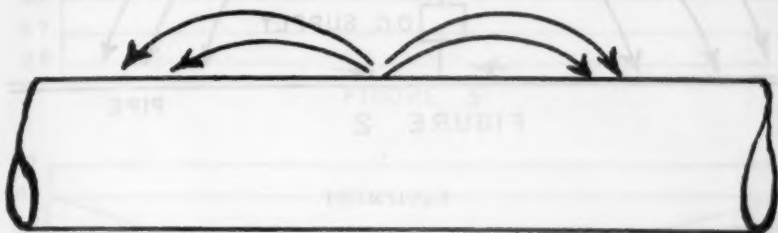


FIGURE 1

As currents leave the pipe they take metal with them. These currents are very small but they may be and generally are discharged in small areas. When it is realized that one ampere continuously leaving a pipe wall will take 20 pounds of metal with it within a year, it is seen that a very small part of an ampere will do much damage when confined to a small area.

The principle of cathodic protection is simply this: A current is caused to flow from the surrounding soil onto the pipe wall in sufficient strength to offset these currents which are trying to leave the pipe. When this is done, corrosion will cease. To make this a little plainer, suppose that it is water which is flowing through the pipe wall and off into the soil. If it were possible to build up a pressure of sufficient intensity in the surrounding soil, then there would be no water leaving the pipe. Of course, that is impossible, but it is possible when dealing with electrical pressures instead of water pressures.

To cause the current to flow onto the pipe wall, it is necessary first to have a source of direct current. The positive terminal of this source is connected to a mass of junk iron buried in the soil near the pipe to be connected. The negative terminal is connected to the pipe. Fig. 2 illustrates the circuit. As the current is forced from the scrap metal, it passes through the soil and onto the pipe and is returned through the wall of the pipe.

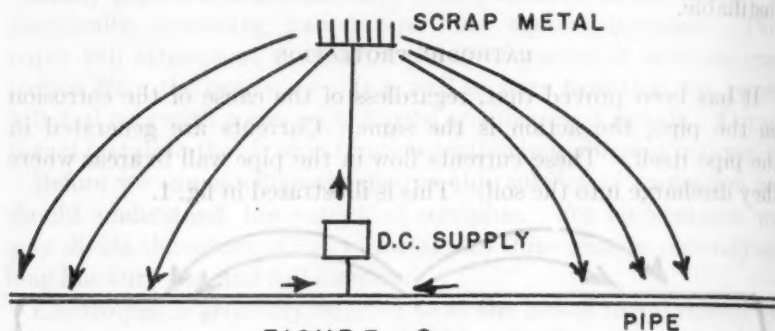


FIGURE 2

## EQUIPMENT

Now, this is a simple circuit but its application proved not so easy. First, it was necessary to obtain the source of direct current. This current is of low voltage and rather high amperage. Rectifiers, which change the alternating current to direct current, were first used where purchased power could be obtained. Motor-generators were also used to some extent. Where power was not available, engine-driven sets have been used with considerable success. This has been the case particularly with natural gas lines. (Fuel to operate the engines was taken from the line.) In many locations, wind driven generators have been successfully used. The development of these different types of generators has been rather slow, but at the present time there are many makes of each type on the market.

One of the first studies was to determine what was necessary to stop the corrosion. After many tests and experiments, it was found that, if the pipe was approximately 0.3 of a volt negative to the soil, corrosion would cease. In other words, if we have a pressure in the soil of 0.3 of a volt above the voltage of the pipe line, we have accomplished our purpose.

After the current is applied to the line, it is necessary to be able to

make tests which enable the engineer to determine the effectiveness of the installation. This is done by measuring the difference in voltage between the pipe and the soil at intervals along the line. To obtain these readings accurately, it is necessary to use a high resistance volt meter and a special terminal to make contact to the earth. These meters and terminals are now on the market.

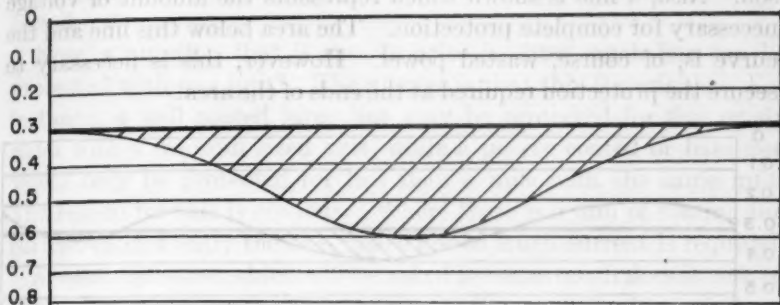


FIGURE 3

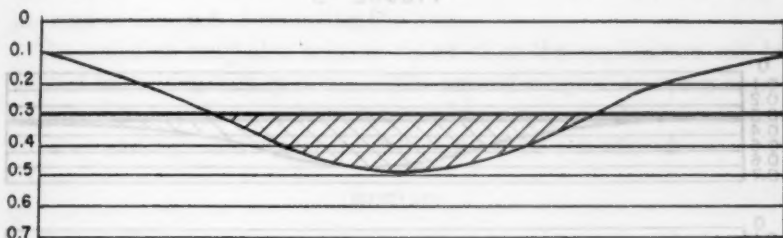


FIGURE 4

## PRACTICAL APPLICATION

\* Referring to fig. 2, it is seen that, when the current enters the pipe from the soil, the current must have a free path back to the generator. This necessitates the bonding of any insulating couplings or fittings in the line. This bonding consists in welding or brazing a comparatively large wire around this fitting to carry the current. When this is done and the current is turned on, voltage readings are taken between the pipe and the soil. These readings may be plotted better to observe the effects of the protection. Fig. 3 is a typical illustration. In this case, the protection is limited to a definite area, and the coating and soil were uniform. Fig. 4 illustrates the effect of

applying the current to an unlimited area. In this case, it is seen that some protection is secured for considerable distance beyond the area of complete protection.

Fig. 5 illustrates a condition where there are considerable changes in the soil and protective coating. In each curve a line is shown which represents no difference in voltage between the pipe and the soil. Also, a line is shown which represents the amount of voltage necessary for complete protection. The area below this line and the curve is, of course, wasted power. However, this is necessary to secure the protection required at the ends of the area.

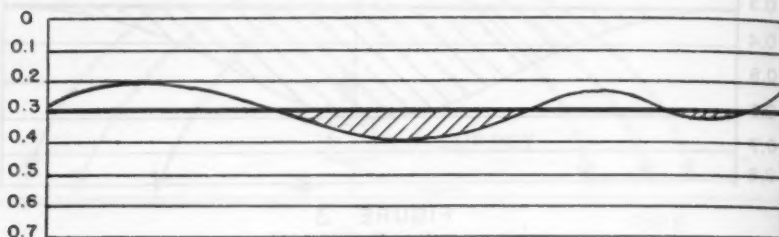


FIGURE 5

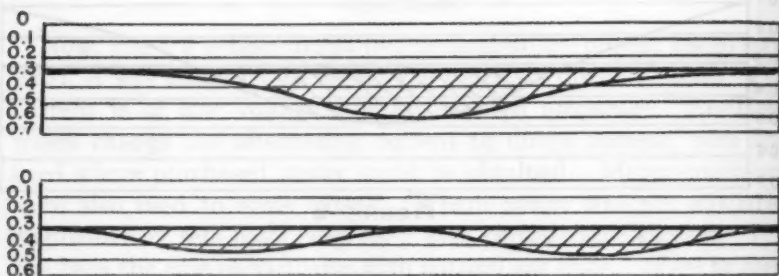


FIGURE 6

Fig. 6 illustrates an actual application on uniformly coated line laid in a uniform soil. The top curve represents the protection secured on four miles of line from one unit. The lower curve shows the protection secured on four miles, but from two units. The amount of wasted power, as represented in the shaded area, is much less in the lower curve.

These units are of the rectifier type, so the current requirements are easily measured. The effect of this wasted power is shown, as follows: The large unit required 60 amperes at 9 volts, or 540 watts.

The combined smaller units required 24 amperes at 3 volts, or 72 watts. From this, it is seen that for economical operation many smaller units are better than a few large ones. However, circumstances and first costs must be considered. In other words, each installation is a separate engineering problem. The writer has installed at least two units with an output of over 100 amperes. In these particular instances, these were the most economical units to install.

Now, a question that is sure to arise is—how much line can be protected with one unit? The answer is that this is variable. For instance, a well coated large line may be protected for five or six miles with a medium sized unit, while a poorly coated or bare line would only be protected for less than a mile with the same unit. The reason for this is obvious. Where there is a film of coating the current cannot enter the line, hence not so much current is required.

Another question which will be asked is—how much does it cost to apply the protection? This, again, varies considerably. In any case, except for very small lines or very short sections, it will be found that the cost of electrical protection will be from 5 to 10 per cent of the cost of renewing the line.

The question may also arise as to whether the application can be applied to distribution systems. The answer is "yes" in many cases. However, the application here is much more complicated on account of other underground structures which must be considered.

#### HISTORY

Electrical protection was first applied by the writer during the summer of 1931. Since then, it has become recognized by practically the entire pipe line industry as a practicable means of combating corrosion. Papers on the subject have been presented at nearly every convention of the American Petroleum Institute and the American Gas Association since 1932. It is used, at least to some extent, by nearly every major pipe line company, both for oil and natural gas.

It has been found by corrosion engineers that the rate of leaks occurring on a pipe line or pipe line system will form a logarithmic curve when plotted. From this, it is possible to predict accurately leak frequencies in the future. Such a curve is shown in fig. 7. The heavy line indicates the leaks as they had occurred up to the time the protection was installed. The dotted line illustrates the number

of leaks that would have occurred had the protection not been applied. The broken line shows the number of leaks that did occur after the protection was installed. This curve is based on the data secured from some fifty installations and is the best proof of the effectiveness of this protection. On this system there have been no pipe replacements since 1933.

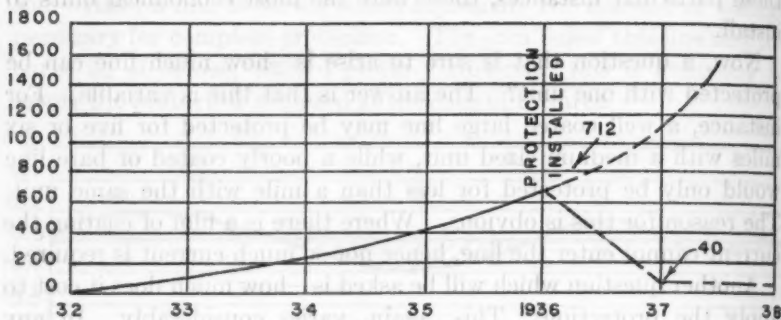


FIGURE 7

## CONCLUSION

No doubt, there are many reasons why this subject has infrequently been discussed by this body. Probably, one of the reasons is that so many of the water lines have been of cast-iron. However, with the advent of large steel lines this subject must be given more consideration.

Cathodic protection has many possibilities other than in its application to pipe lines—possibilities where it may be used advantageously. Well casings may often be so treated. Large steel tank bottoms have been protected against corrosion, both on the outside and the inside. The writer made one rather unusual application in protecting the inside of four large centrifugal pumps. These are cited as examples of the possibilities of this method of combating corrosion.

*Discussion by* ROBERT J. KUHN.\* Mr. Thayer is to be congratulated on the clear method in which he has written his paper. It has brought to those not engaged in this field of endeavor an understanding at least of the principles involved in the process of cathodic protection.

\* Cons. Eng., New Orleans, La.

The operating engineer should not, however, believe that the application of this process to his system is a simple matter since there are many obstacles to be overcome in every installation, nearly every one of which demands an engineering solution. This is very specialized work and requires special instruments, methods of testing, and methods of design and operation.

Cathodic protection involves the introduction of direct current into the structure to be protected and into the surrounding earth. To some extent the effects of such a system resemble those produced by direct-current electric railway operations, i.e., the electrolysis problems on underground metallic structures.

Stray earth currents due to direct-current electric railways were nearly universally regarded, about a decade or more ago, as a liability, something that no one in particular wanted. In the cities and even in the suburbs, electrolysis and corrosion troubles were usually encountered on such underground metallic systems as the water and gas service mains and power, telephone, and telegraph cable sheaths. When failures occurred due to these currents (and frequently when not due to them but when due to natural corrosion), the stray electric currents were usually condemned as a nuisance.

Now since the electric currents used in cathodic protection resemble to so great a degree the old "stray currents," it is important that cathodic protection installations be designed and operated only by those well versed in the ramifications of stray current electrolysis, unless an operator wants to risk involving himself in the damage of other underground structures.

I started on electrolysis mitigation work in New Orleans in 1923. In 1925-1926 I did a great deal of research work on both stray currents and on natural galvanic currents on underground pipes. It was during these investigations that the protective action of stray direct currents in preventing natural corrosion as well as stray current electrolysis, provided the currents were properly directed, was recognized. This led to actual experiments on buried pipe using special sources of direct current, the fundamental circuits of which were the same as used in all cathodic protection systems today.

This work was described in a lengthy paper entitled "Galvanic Currents on Cast Iron Pipes" presented at the First Bureau of Standards corrosion conference held in Washington, D. C. in 1928. There was included some reference to cathodic protection as we now call this system of protection.

To speak of the protective value of stray currents and to be so bold as to mention generating stray currents for the sole purpose of protecting an underground pipe or cable usually brought forth criticism ten years ago, but the work was continued nevertheless. Cathodic protection was applied to a million-dollar steel gas system which has served as a pioneer and a model to the entire gas industry. A paper was presented at the Convention of the American Gas Association held in New Orleans May 9, 1938, the title of which was "Ten Years of Cathodic Protection in New Orleans." This paper described the use of cathodic protection on the steel gas system in New Orleans on which not a single corrosion leak has occurred in spite of the very bad soil and the bad corrosion experience of neighboring pipe lines in similar soil.

Of special interest in Mr. Thayer's paper is the curve showing the number of leaks on a pipe line plotted against years. This curve showed leaks starting in 1932 and accelerating in number until 1936 when 712 leaks occurred. Cathodic protection was installed at this time, and the number of leaks dropped very sharply to 40 in 1937, and lower in 1938. This is a very good record for stoppage of leaks on a pipe line system, but this record does not do full justice to cathodic protection since, in many cases where cathodic protection is applied, leaks due to active corrosion will entirely stop.

It may be possible in Mr. Thayer's case that his record covers sections of his system that received only partial protection from his cathodic protection installations due to great distance, perhaps, from his sources of current generation and distribution and which could not be economically protected. Then too, increases in pressure carried by the lines may have accounted for some of the failures after protection was applied, the increased pressure causing blowouts in badly weakened pipe walls which, however, were possibly no longer corroding. These few failures should not be regarded as a weakness in this method of protection from corrosion. Our experience has shown that when cathodic protection is properly installed and operated and when any weakened pipe has been weeded out of the system, failures from corrosion should be brought down to zero.

## ELECTROLYSIS TROUBLES

### *A Discussion*

BY JOHN B. DEAN AND D. D. GROSS

JOHN B. DEAN. Prior to 1903 the electrolysis problem of the Water Division at St. Louis was very serious. During that year, E. E. Brownell, electrical engineer, was employed to make an electrolysis survey and to report on methods of mitigating this condition. His report showed that enough current was returning from the earth to the rails to remove 125,000 lb. of iron per year from the water mains and other pipes in the streets. Evidently a great amount of iron was being removed as pictures in his report show pipes at eleven places that were deteriorated to such an extent that nails could be driven into them.

Following this investigation the street railway companies improved conditions by better bonding of rail joints, connecting water pipes to rails, and installing copper returns from some of the seriously affected areas. Their work in recent years, with the coöperation of the other public utilities, has been so thorough that our water pipe has been very satisfactorily protected.

When the new plant was built at Howard Bend on the Missouri River, a 60-inch riveted steel conduit, coated by dipping in hot asphalt, was laid to Stacy Park Reservoir, a distance of 9 miles, thence to Hampton Avenue within the city, a distance of 7 miles. In 1926 before it was placed in service, the engineers of the street railway company took potential and current readings along the conduit between the City and Stacy Park Reservoir and advised that it be connected to the rails of the Kirkwood-Ferguson line. This was done and subsequent readings indicated that the conduit was safe from electrolysis.

No trouble was experienced until 1932 when a girth seam leaked

---

A discussion presented at the New Orleans convention, April 27, 1938, by John B. Dean, Water Com., St. Louis, Mo., and D. D. Gross, Ch.Eng., Board of Water Com., Denver, Colo.

at North and South Road and pitting of the pipe was noticed. This was attributed to the laying of a county water main across the steel conduit. A bond to the water main was installed at this point and there was no further trouble until 1935 when a few leaks developed at Ladue Road and at North and South Road. These were repaired by driving in tapered pins, and welding them to the wall of the pipe. The repairs were quickly and easily made and the conduit was bonded to the county water pipe at Ladue Road.

No further trouble was experienced until August, 1937, when leaks occurred where the conduit crosses North and South Road and along 372 ft. of conduit east of Price Road. At these two places there were 30 holes through the pipe and 2,150 pits. The services of a welder for 235 hours were required to repair the holes and deep pits. The conduit was again put in service and eight additional leaks immediately developed which had to be uncovered and welded. In each case there were several holes accompanied by extensive pitting which required 130 hours welding time to repair.

This trouble was far more serious than had ever been experienced before. It occurred at some points far removed from any other conductors to which the current could be flowing, and the pitting was distributed over large areas.

While repairs were being made, the engineers of the street railway company, with the coöperation of the telephone company, obtained potential readings from which they calculated that our conduit was carrying west from the city approximately 50 amperes, about half of which was being drawn off by a bond at Price Road. The remainder was evidently passing to the earth with the resultant deterioration of pipe. Anyone would naturally assume that this is stray current from the street railway lines; but when all of the generating stations were shut down for a period of  $1\frac{1}{2}$  minutes, the potential between our conduit and other conductors increased instead of decreased. This would indicate that the stray currents have a protective rather than a destructive effect, and that our troubles are the result of galvanic action. However, there have been no leaks, and no pitting has been discovered west of the reservoir, where for a distance of nearly four miles the conduit is laid in the same kind of soil as occurs to the east between Stacy Park and the City, and galvanic action would be expected to occur similarly along both sections of conduit.

Are we afflicted with stray currents or galvanic action?

D. D. GROSS. I propose to discuss electrolysis troubles—both electrolysis due to stray currents from electric railways and that from galvanic soil currents, but more particularly the two when acting together. Either is trouble enough when acting alone, but when acting together the damage they can do is greater and the deterioration of the pipe lines progresses much more rapidly.

I have also in mind the present status of the electric street railway which has an important bearing on the electrolysis situation at this time, and challenges the water works man to the use of greater care in protecting his property. The coming of the rubber tired gasoline motor bus and the automobile put many of the electric tramways out of business, especially in the smaller cities and in the outlying districts in the larger cities, and to that extent ended electrolysis troubles from that source. I am advised that improvements in electric tram cars will probably make desirable their use indefinitely in congested traffic areas.

It is not necessarily the most used electric lines that cause the most trouble. If a line carries little traffic, it may be under consideration for abandonment, and in that case the tracks are likely to be in poor condition with more current leaving the tracks than would be the case were the line well maintained. It may be that in order to hold a franchise a traction company will retain tracks that are not used, that is, the tracks may be in place. They may, in fact, even be covered with surfacing material, but traffic is taken over other routes or is provided for by motor buses. Under these conditions the tracks are not maintained in the same good condition that would be the case if they were in use, yet they are in the ground and if they are connected with other lines, they carry more or less current back and forth between the active parts of the system.

New methods of operation replace the old in order to meet the new traffic conditions. Re-routing of cars and changing of schedules to facilitate the combined operation of bus and tram lines make a change in the routes and intensity of flow of return currents, and perhaps the time of operation of a substation is changed. It is found under new conditions the station is required only a few hours during the peak load. Drainage may have been installed to the bus bars in this station, to reduce the potential on the water main, but under the new conditions the flow of current when the station is out of service may be in the opposite direction, requiring the installation of an automatic switch that will permit the flow of current from the main

to the station when the station is in operation but when the station is out of service will prevent the flow, in the opposite direction, of current that may originate by flow along the negatives from active stations.

In Denver, from the very early days of the tramway, we have been committed to a policy of drainage as a means of mitigating electrolysis injury to the pipe system from current returning to the substation and the power house by way of the pipe system. We have not, however, been fully and wholly committed to this policy because the system has not always been in charge of the same men, and the policy of the proper steps for the mitigation of electrolysis was not always the same. After the early installation of drainage systems the responsibility for operating the water plant fell into other hands. These men, while not removing the old drainage systems, made no particular effort to retain them in good serviceable condition. They did not install new drains when new substations were built. So, in Denver's system and the interurban lines extending to nearby cities and towns, we are able to compare the relative condition of our piping system in the vicinity of substations in which there was no drainage as compared with those in which drainage was provided. Moreover, we have had opportunity from time to time to view the condition of our piping at points distant from the substations.

The distribution system in Denver, with the exception of small temporary developing mains, is practically all of cast iron. Practically all of the joints are made with lead. We have tried a few blocks of steel pipe and have also made a few installations of cast-iron pipe in which lead substitutes were used as joint material.

The first water main, 15-inch cast-iron pipe, was installed in Denver in 1871 and is still in use. It extends from the business center of the city, where naturally the heaviest electric tramway traffic exists, in the direction of and almost to the power house. The soil in this district is not of a corrosive nature. The water mains at the power house are drained by copper drains connected to the negative bus bars in the power house. This condition has existed for many years; and this sixty-seven year old main is in excellent condition except for tuberculation on the inside.

Compared with this installation, I have in mind a 16-inch main installed something over thirty years ago. This main passes near a substation that was built about twenty-five years ago. This main also passed under a tram track that was poorly maintained and has

now been abandoned. There was no drainage provided between this main and the substation. Some five years ago we had a serious break on this main which we ascribed to stray current electrolysis, although the ground is corrosive and galvanic action may have had a part in the damage to the main. Since that time drainage has been installed between this main and the substation.

There is a question as to whether a system of insulation or drainage is the better as a means of electrolysis mitigation. It is claimed that drainage is a protection to the piping in the immediate vicinity of the power house or substation, but that it distributes the damage which may be done by the stray electric currents more uniformly over the entire system. We have been able to tell something of the condition over the entire system, and also the conditions at the substation where drainage was installed and where it was not installed, both in the cases mentioned and at other locations, and we have come to the conclusion that we are in favor of the drainage system.

We realize that the first and most important item in electrolysis mitigation is the proper bonding of tramway rails. In Denver at the present time, electric welded joints are being used when tracks are relaid. These give excellent results in eliminating the loss of current from the rails.

Recently we have organized an Electrolysis Committee in Denver and all the municipal organizations and public utilities having property in the Denver area, which are involved either in creating conditions which may cause electrolysis or in possession of property which may be damaged by electrolysis, are taking a very active interest in the functioning of the new organization.

## TYPHOID IN THE LARGE CITIES OF THE UNITED STATES IN 1937\*

As in the preceding annual reviews, data have been obtained from the same ninety-three cities for which the annual statistical tabulations have been made. A communication addressed to the health officer of each city requested not only the total number of deaths from typhoid during the year 1937 but also a statement as to how many of these were among nonresidents. Furthermore, a comment was invited on any special outbreak of typhoid or any unusual protective measures taken to guard against this disease.

It is becoming increasingly difficult to secure an estimate of population for these cities. The willingness of the health officer to provide such estimate and personal determination of population trends vary throughout the country. The United States Census Bureau not being prepared to furnish estimates of population, we have been compelled to fall back on the judgment of the local health officer. Some of these officers take no credit for population increase since the 1930 census. Others would seem to have an exaggerated notation of population increase. One health officer records an increase of 15 per cent in population in but a single year and this in one of the conservative and rather stable communities near the Eastern seaboard. In spite of all these variations in judgment and the inevitable mistakes which have been made in estimating the population figures, we feel that the rates should be recorded, with, however, the proviso that they must be reviewed and corrected in light of the 1940 census. It is likely that the errors in no instance will be significant. In the few instances in which the local health department did not furnish an estimate for 1937, either the 1930 census figures or the population data submitted for 1936 were used in determining the rates.

\* Reprinted, by permission, from the Journal of the American Medical Association (Vol. 111, pp. 414-418, July 30, 1938). Previous reproductions of this annual summary have appeared in the Journal of the American Water Works Association as follows: Vol. 20, p. 257; Vol. 21, p. 963; Vol. 22, p. 1122; Vol. 23, p. 1059; Vol. 24, p. 1066; Vol. 25, p. 1157; Vol. 26, p. 939; Vol. 27, p. 1593; Vol. 28, p. 1123; and Vol. 29, p. 1177.

Paratyphoid has been excluded. In tables 1 to 8 inclusive (as well as in table 10) a special note has been made of cities in which all deaths occur among nonresidents. Similar notation has been added for the death rates for 1936 but in no instance for preceding years. Another symbol has been used to indicate those cities in which more than one third of the reported deaths were stated to have been among nonresidents. We have already mentioned the errors which will creep into the figures as a result of inaccurate census data. More important, we believe, are the variations in considering the classification of deaths among nonresidents and local practice with respect to case hospitalization. As an example, New York reports but one nonresident death in a total of twenty-five. The absence of nonresident deaths from any cause in New York means that no individual, whose usual residence is outside New York, died anywhere within the city limits from that particular cause. Deaths of nonresidents are not allocated to other jurisdictions. In Chicago, on the other hand, the figures presented would not include nonresidents who die in Chicago but whose usual abode is within the state of Illinois. Such cases would be allocated to their usual place of residence within the state. No correction is made for nonresidents who do not live in Illinois. It is reported that in 1937 no allocations of deaths from typhoid were made. On the other hand the regulations with regard to hospitalization of typhoid cases in Chicago are very rigid and would tend to exclude cases from neighboring communities. In some other cities, as for example Detroit, local regulations encourage the admission of communicable diseases to city hospitals. In this particular city a lease of land on which the communicable disease hospital is located makes it mandatory that all county communicable diseases be hospitalized on such premises and this naturally adds to the nonresident load. In Portland, Oregon, the city isolation hospital is located outside of the city limits in Multnomah County, and deaths from communicable diseases do not ordinarily appear in the city's vital statistics. There seem to be innumerable minor variations in local practice which but add to the statistical confusion. It is hoped that some day a common denominator can be established on which to base a uniform practice for statistical summaries. Such errors of course will occur more frequently in the figures for diphtheria than for typhoid, as the latter disease is more often cared for in a general hospital.

It is apparent that there is great variation in significance attached

to the extent of a local outbreak. Jacksonville reports no unusual prevalence of typhoid with a death rate of 4.0, while other cities are concerned with a death rate which does not exceed 1.0. Many of the Southern cities serve as hospital centers for surrounding rural areas in which full time local health service has not been effectively established. The local hospitalization plans as well as the inadequacy of preventive care for Negroes presents a significant reason for the continuation of a relatively high typhoid mortality in some of the Southern cities.

TABLE 1

*Death rates of fourteen cities in New England states from typhoid per hundred thousand of population*

	1937	1936	1935	1931- 1935	1926- 1930	1921- 1925	1916- 1920	1911- 1915	1906- 1910
Bridgeport.....	0.0	0.0	0.0	0.3	0.5	2.2	4.8	5.0	10.3
Somerville.....	0.0	0.0	0.0	0.4	1.3	1.6	2.8	7.9	12.1
Waterbury.....	0.0	0.0	2.0	0.4	1.2	1.0	8.0	18.8	....
Fall River.....	0.0	0.9	0.9	0.2†	2.2	2.3	8.5	13.4	13.5
Lynn.....	0.0	1.0	1.0	0.2	1.5	1.6	3.9	7.2	14.1
New Bedford.....	0.0	1.8	0.0	1.1†	1.5	1.7	6.0	15.0	16.1
Providence.....	0.4	0.8	0.8	1.1	1.3	1.8	3.8	8.7	21.5
Boston.....	0.4*	0.1*	0.5	0.6	1.2	2.2	2.5	9.0	16.0
Worcester.....	0.5*	0.0	0.5	0.6	1.0	2.3	3.5	5.0	11.8
Springfield.....	0.7*	0.0	0.0	1.0	0.4	2.0	4.4	17.6	19.9
Cambridge.....	0.8	0.0	0.0	0.9	2.1	4.3	2.5	4.0	9.8
Lowell.....	1.0	1.0	1.0	1.0†	2.6	2.4	5.2	10.2	13.9
Hartford.....	1.1	0.5	0.6	1.2	1.3	2.5	6.0	15.0	19.0
New Haven.....	1.2	1.2	0.0	0.7	0.6	4.4	6.8	18.2	30.8

\* All typhoid deaths were stated to be in nonresidents.

† Rate computed from population as of April 1, 1930, as no estimate for July 1, 1933, was made by the Census Bureau.

Six of the large New England cities report no death from typhoid in 1937 (table 1). Bridgeport and Somerville report no death for four years in succession. The record for Springfield with no deaths for three years in succession was marred in 1937 by the death of a nonresident. It is only fair that account should be taken of this fact and mention made that Springfield continues its excellent record with no death among residents for four consecutive years. Worcester had but one death in 1936 and Boston but three deaths; all of these are reported as having occurred in nonresidents. The New England cities as a whole (population 2,640,933) again report the lowest rate

for any group. Their rate of 0.45 is not quite as low as that of 1936 (0.42). There were recorded twelve deaths in 1937 (but 11 deaths in 1936).

The Middle Atlantic states have a group rate which is but slightly less than for the preceding two years (0.51 in 1937, 0.56 in 1936).

TABLE 2

*Death rates of eighteen cities in Middle Atlantic states from typhoid per hundred thousand of population*

	1937	1936	1935	1931- 1935	1926- 1930	1921- 1925	1916- 1920	1911- 1915 *	1906- 1910
Syracuse.....	0.0	0.0	0.5	0.8	0.8	2.3	7.7	12.3	15.6
Utica.....	0.0	0.0	1.0	0.6	1.1	3.9†	...	...	...
Yonkers.....	0.0	0.7	1.4	0.7	0.5	1.7	4.8	5.0	10.3
Newark.....	0.0	0.2	0.0	0.3	0.9	2.3	3.3	6.8	14.6
Rochester.....	0.0	0.6†	0.3	0.4	1.7	2.1	2.9	9.6	12.8
Paterson.....	0.0	0.7	0.0	0.9	1.0	3.3	4.1	9.1	19.3
Reading.....	0.0	1.8	0.9	0.4	1.6	6.0	10.0	31.9	42.0
Buffalo.....	0.2*	0.3	0.5	0.6	2.7	3.9	8.1	15.4	22.8
New York.....	0.3	0.4	0.5	0.8	1.3	2.6	3.2	8.0	13.5
Jersey City.....	0.3	0.6*	0.0	0.2	0.9	2.7	4.5	7.2	12.6
Scranton.....	0.7*§	0.0§¶	0.0§	1.4	1.8	2.4	3.8	9.3	31.5
Pittsburgh.....	0.7†	0.7†	0.6	0.9	2.4	3.9	7.7	15.9	65.0
Elizabeth.....	0.8	0.8	0.0	0.9	1.6	2.4	3.3	8.0	16.6
Trenton.....	0.8*	0.8*	0.0	1.1	2.1	8.2	8.6	22.3	28.1
Erie.....	0.8*	0.8*	0.0	1.0	0.9	2.3	6.9	49.0	46.6
Albany.....	1.3†	1.5	0.8	1.1	1.8	5.6	8.0	18.6	17.4
Philadelphia.....	1.4	0.7	0.9	0.9	1.1	2.2	4.9	11.2	41.7
Camden.....	1.6	0.8	2.5	2.8	4.4	5.9	4.9	4.5	4.0

\* All typhoid deaths were stated to be in nonresidents.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

‡ Incomplete data.

§ Typhoid deaths for Scranton furnished by Pennsylvania Department of Health, Harrisburg.

¶ Rate computed from 1930 census population, as no local estimate was given.

|| Corrected rate. In review for 1936 Yonkers reported cases instead of deaths.

There have been no deaths recorded in Syracuse and Utica for the two years 1936 and 1937. Scranton reports one death of a non-resident. As in the case of Springfield, mention should be made of the fact that Scranton has passed through four consecutive years

with no resident death. The honor roll for this group of cities has improved over 1936, there being seven cities which record no death in 1937, four additional cities which report all deaths among non-residents, and two additional cities in which one third or more of the deaths were stated to be in nonresidents. Unfortunately, in providing the figures for Yonkers in 1936 the statistical clerk of the local health department sent in the number of cases although the questionnaire clearly specified deaths. As a result of this error seven deaths (instead of one) were recorded in the tables for the preceding year. Appropriate corrections have been entered in the current review. Every

TABLE 3

*Death rates of nine cities in South Atlantic states from typhoid per hundred thousand of population*

	1937	1936	1935	1931-1935	1926-1930	1921-1925	1916-1920	1911-1915	1906-1910
Tampa.....	0.0	0.0	6.6	3.0	3.8	19.1	43.9*	....	....
Norfolk.....	0.8	0.0	5.4†	4.2	2.2	2.8	8.8	21.7	42.1
Baltimore.....	1.2	0.9	1.5	1.4	3.2	4.0	11.8	23.7	35.1
Wilmington.....	1.8	0.9	0.9†	1.5	3.1	4.7	25.8*	23.2*	33.0
Washington.....	1.9	1.6	2.6	2.6	2.8	5.4	9.5	17.2	36.7
Atlanta.....	1.9†	3.2†	4.6	7.2	11.1	14.5	14.2	31.4	58.4
Richmond.....	3.2†	2.7	2.7	2.5	1.9	5.7	9.7	15.7	34.0
Jacksonville.....	4.0	1.3	0.0	1.7	4.4	...	...	...	...
Miami.....	6.3	3.1†	2.8	2.2	3.5	...	...	...	...

\* Incomplete data.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

‡ Rate computed from population as of April 1, 1930, as no estimate for July 1, 1933, was made by the Census Bureau.

health officer should make it his practice to review personally and check reports giving the number of cases and deaths from the various communicable diseases. In obtaining the figures for the current year a similar mistake was made by the health officer of one of our largest cities. Fortunately, the reviewer caught the mistake before irreparable damage had accrued. New York was undoubtedly spared the embarrassment of an outbreak of typhoid among non-residents when in August 1937 a transatlantic steamer arrived in the harbor with twenty-five suspicious typhoid cases among its crew. Within eighteen hours the health department laboratory had confirmed the diagnosis. The liner sailed the following day without

passengers, returning to its home port with the entire crew including the sick. During the next five weeks there occurred fifty-three cases of typhoid among the crew of this ship, with one death. So far as is known none of the passengers became ill.

The record for the South Atlantic cities is not as good as for 1936 but continues to show a marked improvement over the rate for 1935 (1.96 in 1937, 1.55 in 1936, 2.58 in 1935). There is but one city (Tampa) which reports no death. This is the second consecutive year with no typhoid death in Tampa, which is a significant improvement over the 1935 rate of 6.6. Norfolk, which also reported no death in 1936 (a marked decline from the rate of 5.4 in 1935), reports one resident death in 1937. These two cities, however, continue to lead the list for the nine in their group. Jacksonville has not continued her excellent record of the past few years with a quinquennial average of 1.7 for 1931-1935 and no deaths in 1935; the rate has increased to 4.0 in 1937. This is attributed to the fact that Jacksonville serves as a hospital center for six or seven rural counties surrounding the city. Of the six deaths in 1937, however, it is recorded that five of these occurred among residents. The tendency for residents of urban centers to return from vacations and short trips to neighboring rural areas where sanitary facilities are not of the best is well known to all epidemiologists.

In the East North Central states the rate has again fallen to a low almost equivalent to that of 1937. This group of cities continues to remain in third place, first place being maintained by the New England group and second place by the Middle Atlantic. New close contenders for third place are the West North Central cities and the Mountain and Pacific group. In the New England, Atlantic and West North Central states there is no city with a rate in excess of 2.0. In the East North Central states there are two such cities (Evansville, Flint) but in each of these cities one third or more of the reported typhoid deaths were stated to be in nonresidents. There are four cities in the group with no typhoid death. Evansville, following an impressive reduction in death rate from 4.7 to 1935 to 0.0 in 1936, reports three deaths in 1937, only one of which, however, occurred in a resident. Of five deaths in Flint, two were stated to be in nonresidents. In August 1937 there occurred an outbreak of thirteen cases with five deaths. The source of infection was ascribed to a food handler, unknown and unlocated until about the middle of the outbreak. In Toledo it is stated that all four deaths were in non-

residents. It is recorded that twenty-two cases of typhoid occurred in a camp for girls and since that time typhoid vaccination has been made compulsory for admission to such camps. Despite the great flood in the Ohio Valley, which interfered with the normal operation of the municipal water works and resulted in the flooding of the vast valley areas of Cincinnati, there were but two resident typhoid

TABLE 4

*Death rates of eighteen cities in East North Central states from typhoid per hundred thousand of population*

	1937	1936	1935	1931- 1935	1926- 1930	1921- 1925	1916- 1920	1911- 1915	1906- 1910
Fort Wayne.....	0.0	0.0	0.0	2.2	4.2	12.9	7.3	.....	.....
South Bend.....	0.0	0.0	0.9	0.7	.....	.....	.....	.....	.....
Milwaukee.....	0.0	0.3	0.0	0.2	0.8	1.6	6.5	13.6	27.0
Canton.....	0.0	1.0§	0.9	0.9	1.4	3.3	8.9	.....	.....
Chicago.....	0.3	0.3	0.4	0.4	0.6	1.4	2.4	8.2	15.8
Detroit.....	0.3	0.5	0.3	0.6	1.3	4.1	8.1	15.4	22.8
Cleveland.....	0.5	1.0	0.6	1.1	1.0	2.0	4.0	10.0	15.7
Grand Rapids.....	1.0*	0.6*	0.0	0.2	1.0	1.9	9.1	25.5	29.7
Youngstown.....	1.1	1.1†	0.0	1.1	1.1	7.2	19.2	29.5	35.1
Toledo.....	1.2*	1.0†	1.3	1.3	3.0	5.8	10.6	31.4	37.5
Indianapolis.....	1.3	0.8†	1.3	1.2	2.7	4.6	10.3	20.5	30.4
Cincinnati.....	1.3†	1.9†	1.3	1.4	2.5	3.2	3.4	7.8	30.1
Dayton.....	1.4†	1.8†	1.0	0.8	1.9	3.3	9.3	14.8	22.5
Columbus.....	1.5	3.7*	2.0	2.0	2.1	3.5	7.1	13.8	40.0
Akron.....	1.6†	0.8†	0.7	0.8	1.5	2.4	10.6	21.0	27.7†
Peoria.....	1.7*	1.7*	0.0	0.9	0.2	3.7	5.7	16.4	15.7†
Evansville.....	2.7†	0.0	4.7	1.9	6.2	5.0	17.5	32.0	35.0
Flint.....	3.0†	1.2	0.6	0.7	1.6	4.6	22.7	18.8	46.9

\* All typhoid deaths were stated to be in nonresidents.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

‡ Incomplete data.

§ Rate computed from 1930 census population, as no local estimate was given.

deaths in 1937. Of the total of six deaths, four were in nonresidents. The health department attributes this splendid record to the extraordinary precautions taken to maintain the sanitary facilities of the city during flood time, the requirement of boiling all water, and the program of typhoid vaccination. Milwaukee returns to the honor roll with no death in 1937. Chicago and Detroit maintain their excellent low rates for cities of their size (0.3).

The six cities in the East South Central group show a marked lowering in the death rate (3.35 in 1936, 2.10 in 1937). This new rate is less than one-half the average for the quinquennium 1931-1935 (4.81). The actual number of deaths in these six cities dropped from forty-three in 1936 to twenty-eight in 1937. Louisville and Nashville record no death in a resident in 1937. Again this is a noteworthy record for Louisville—a city literally covered with water during the flood. The two deaths which did occur in 1937 were both in nonresidents. It is estimated that during the time of the flood 221,000 citizens received vaccination for typhoid. Chattanooga, with no death in 1936, reports two deaths in residents in 1937.

TABLE 5

*Death rates of six cities in East South Central states from typhoid per hundred thousand of population*

	1937	1936	1935	1931-1935	1926-1930	1921-1925	1916-1920	1911-1915	1906-1910
Louisville.....	0.6*	1.4†	1.6	2.3	3.7	4.9	9.7	19.7	52.7
Nashville.....	1.2*	4.4†	7.0	5.6	18.2	17.8	20.7	40.2	61.2
Birmingham.....	1.4	5.0§	4.0	3.9	8.0	10.8	31.5	41.3	41.7
Chattanooga.....	1.7	0.0	2.4	4.7	8.0	18.6	27.2	35.8†	....
Knoxville.....	3.2	4.1	5.4	5.7	10.7	20.8	25.3†	....	....
Memphis.....	4.9†	4.7†	5.0	7.9	9.3	18.9	27.7	42.5	35.3

\* All typhoid deaths were stated to be in nonresidents.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

‡ Incomplete data.

§ Rate computed from 1930 census population, as no local estimate was given.

Birmingham reports four deaths, all in residents. Memphis continues to have a high rate, which deserves special comment. Among the fourteen deaths six were in residents, eight in nonresidents. There was no death from typhoid among the white residents of Memphis either in 1937 or in 1936 and only one white death in 1935. During the past three years there have occurred eighteen deaths in residents from typhoid, of which seventeen were in Negroes. Since the Negro population of Memphis is but 38 per cent of the total, the ratio of Negro to white deaths is statistically significant. The typhoid problem of Memphis involves the Negro, his mode of life, his custom of wandering into the cotton lowlands of the adjoining states, the inadequacy of whole time local health units, and

the lack of an immunization program. During the flood period in January and February 1937, 30,000 refugees passed through the temporary camps established in Memphis and were vaccinated against typhoid. Apparently the flood had little effect on the incidence of the disease.

The West North Central group again reports substantially the same number of deaths as have occurred during the past two years (twenty-one in 1937, twenty-two in 1936, twenty-three in 1935). Three cities record no death in 1937 (Duluth, St. Paul, Wichita). In Duluth there has been no death for two consecutive years and its excellent record is maintained. In Minneapolis and Kansas

TABLE 6

*Death rates of nine cities in West North Central states from typhoid per hundred thousand of population*

	1937	1936	1935	1931-1935	1926-1930	1921-1925	1916-1920	1911-1915	1906-1910
Duluth	0.0	0.0	1.0	1.0	1.1	1.7	4.4	19.8	45.5
St. Paul	0.0	0.7	0.3	0.7	1.4	3.4	3.1	9.2	12.8
Wichita	0.0	1.9	0.0	0.7	1.2	6.3	...	...	...
Minneapolis	0.2*	0.0	1.2	0.8	0.8	1.9	5.0	10.6	32.1
Des Moines	0.7	2.8	2.1	2.1	2.4	2.2	6.4	15.9	23.7
Kansas City, Kan.	0.8*	2.3	1.6	1.1	1.7	5.0	9.4	31.1	74.5†
St. Louis	1.1†	0.8	0.7	1.6	2.1	3.9	6.5	12.1	14.7
Omaha	1.3	0.9*	0.0	0.9	1.3	3.3	5.7	14.9	40.7
Kansas City, Mo.	1.4†	0.5	1.0	1.5	2.8	5.7	10.6	16.2	35.6

\* All typhoid deaths were stated to be in nonresidents.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

‡ Incomplete data.

City, Kansas, the one death each was stated to be in nonresidents. Following a period of two consecutive years with no death and the recording of two resident deaths in 1936, Wichita returns to the honor roll with no death in 1937.

The eight cities in the West South Central group show a marked improvement over the rates for preceding years (2.34 in 1937, 3.99 in 1936, 3.82 in 1935). The 1937 rate is approximately one half of the average for the five year period 1931-1935 (5.36). The actual number of deaths in this group of cities dropped from seventy-nine in 1936 to forty-nine in 1937. In 1936 three of the eight cities recorded rates in excess of 4.0. In 1937 there was no city with a death

rate as high as 4.0. In Dallas it is stated that all of the nine deaths recorded were in nonresidents. Of twelve deaths reported for New Orleans, nine were in nonresidents. Again it is well to emphasize a variation in statistical practices encountered throughout the country. Table 7 records the death rate in Dallas in 1937 as 3.0. Assuming that all of the nine nonresident deaths occurred in persons residing within the state of Texas and further assuming the same statistical practice which is used in Chicago, where nonresident deaths are charged back to Illinois communities, the death rate in Dallas in 1937 would be 0.0 instead of 3.0. This but emphasizes the need of a common basis on which to record statistical evidence.

TABLE 7

*Death rates of eight cities in West South Central states from typhoid per hundred thousand of population*

	1937	1936	1935	1931-1935	1926-1930	1921-1925	1916-1920	1911-1915	1906-1910
Tulsa.....	0.0	0.7§	0.7	1.1	8.3	16.2†	....	....	....
El Paso.....	0.0	6.8§	7.6	4.9	9.1	10.8	30.7	42.8	....
Houston.....	2.0	3.8	2.2	3.2	4.8	7.6	14.2	38.1	49.5†
Fort Worth.....	2.2	3.3	1.2	4.6	5.9	6.1	16.3†	11.9	27.8
New Orleans.....	2.3†	6.5†	7.4	9.6	9.9	11.6	17.5	20.9	35.6
Dallas.....	3.0*	1.5*§	2.9	5.4	7.3	11.2	17.2	....	....
Oklahoma City.....	3.1	4.3§	2.5	4.3	7.4†	....	....	....	....
San Antonio.....	3.8	2.7	3.3	4.2	4.6	9.3	23.3	29.5	35.9

\* All typhoid deaths were stated to be in nonresidents.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

‡ Incomplete data.

§ Rate computed from 1930 census population, as no local estimate was given.

The cities in the Mountain and Pacific states show a continued reduction in the rate (0.68 in 1937, 0.80 in 1936). There were recorded twenty-eight deaths in 1937, thirty-two deaths in 1936. In 1937 there were four cities with no death (Seattle, Long Beach, Spokane, Tacoma). There was but one city with a rate in excess of 2.0 (Denver). Among ten deaths occurring in Los Angeles, six were in nonresidents. Of four deaths in San Francisco, three were in residents. Tacoma, after two consecutive years of freedom from typhoid and the reporting of one resident death in 1936, returns in 1937 to the honor roll with no deaths.

## THE HONOR ROLL

The number of cities with no death from typhoid has increased to twenty-seven. In 1936 there were but eighteen such cities. However, in 1935 there were twenty-four cities on the honor roll. We pay special tribute to the nine cities listed in table 9, which report no typhoid death in 1936 and 1937. Bridgeport and Somer-

TABLE 8

*Death rates of eleven cities in Mountain and Pacific states from typhoid per hundred thousand of population*

	1937	1936	1935	1931- 1935	1926 1930	1921- 1925	1916- 1920	1911- 1915	1906- 1910
Seattle.....	0.0	0.5	0.8	0.6	2.2	2.6	2.9	5.7	25.2
Long Beach.....	0.0	0.6*	0.0	0.2	1.1	2.1†	...	...	...
Spokane.....	0.0	0.8	0.8	1.4	2.2	4.4	4.9	17.1	50.3
Tacoma.....	0.0	0.9	0.0	0.7	1.8	3.7	2.9	10.4	19.0
Oakland.....	0.3	0.3	1.7	1.0	1.2	2.0	3.8	8.7	21.5
Portland.....	0.3	0.6	1.6	0.8	2.3	3.5	4.5	10.8	23.2
San Francisco.....	0.6	0.3†	0.8	0.8	2.0	2.8	4.6	13.6	26.3
Salt Lake City.....	0.7	0.0	1.4	1.0	1.9	6.0	9.3	13.2	41.1
Los Angeles.....	0.7†	1.0†	0.9	0.8	1.5	3.0	3.6	10.7	19.0
San Diego.....	1.6†	1.8†	0.0	1.3	1.0	1.6	7.9	17.0	10.8
Denver.....	2.7	2.0	0.7	1.8	2.6	5.1	5.8	12.0	37.5

\* All typhoid deaths were stated to be in nonresidents.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

‡ Incomplete data.

TABLE 9

*Nine cities with no typhoid death in 1936 and 1937*

Bridgeport*	Somerville*	Tampa
Duluth	South Bend	Utica
Fort Wayne†	Syracuse	Waterbury

\* No typhoid death in four years.

† No typhoid death in three years.

ville have had no typhoid death in four consecutive years; Fort Wayne in three consecutive years. There remains but one city in the third rank with a death rate in excess of 5.0. Several of the cities in the first rank would appear on the honor roll were they not charged with deaths in nonresidents.

TABLE 10

*Death rates from typhoid in 1937*

## Honor Roll: No Typhoid Deaths (Twenty-Seven Cities)

Bridgeport	Newark	St. Paul
Canton	New Bedford	Syracuse
Duluth	Paterson	Tacoma
El Paso	Reading	Tampa
Fall River	Rochester	Tulsa
Fort Wayne	Seattle	Utica
Long Beach	Somerville	Waterbury
Lynn	South Bend	Wichita
Milwaukee	Spokane	Yonkers

## First Rank: from 0.1 to 1.9 Deaths per Hundred Thousand (Fifty-Two Cities)

Buffalo..... 0.2*	Scranton..... 0.7*	Albany..... 1.3†
Minneapolis..... 0.2*	Springfield..... 0.7	Cincinnati..... 1.3†
Chicago..... 0.3	Cambridge..... 0.8	Indianapolis..... 1.3
Detroit..... 0.3	Elizabeth..... 0.8	Omaha..... 1.3
Jersey City..... 0.3	Erie..... 0.8*	Birmingham..... 1.4
New York..... 0.3	Kansas City, Kan. 0.8*	Dayton..... 1.4†
Oakland..... 0.3	Norfolk..... 0.8	Kansas City, Mo. 1.4†
Portland..... 0.3	Trenton..... 0.8*	Philadelphia..... 1.4
Boston..... 0.4*	Lowell..... 1.0	Columbus..... 1.5
Providence..... 0.4	Grand Rapids... 1.1*	Akron..... 1.6†
Cleveland..... 0.5	Hartford..... 1.1	Camden..... 1.6
Worcester..... 0.5*	St. Louis..... 1.1†	San Diego..... 1.6†
Louisville..... 0.6*	Youngstown..... 1.1	Chattanooga... 1.7
San Francisco... 0.6	Baltimore..... 1.2	Peoria..... 1.7*
Des Moines..... 0.7	Nashville..... 1.2*	Wilmington..... 1.8
Los Angeles..... 0.7†	New Haven..... 1.2	Atlanta..... 1.9†
Pittsburgh..... 0.7†	Toledo..... 1.2*	Washington..... 1.9
Salt Lake City... 0.7		

## (Second Rank: from 2.0 to 4.9 (Thirteen Cities)

Houston..... 2.0	Dallas..... 3.0*	Knoxville..... 3.2
Fort Worth..... 2.2	Flint..... 3.0†	San Antonio..... 3.8
New Orleans.... 2.3†	Oklahoma City... 3.1	Jacksonville.... 4.0
Denver..... 2.7	Richmond..... 3.2†	Memphis..... 4.9†
Evansville..... 2.7†		

## Third Rank: from 5.0 to 6.3 (One City)

Miami..... 6.3
----------------

\* All typhoid deaths were stated to be nonresidents.

† One third or more of the reported typhoid deaths were stated to be in nonresidents.

An examination of table 11 shows the distinct swing "to the right." A new high of twenty-seven has been attained for cities with no deaths; a new low of but one for cities with a death rate from 5.0 to 9.9.

TABLE 11  
*Number of cities with various typhoid death rates*

	NUMBER OF CITIES	10.0 AND OVER	5.0 TO 9.9	2.0 TO 4.9	1.0 TO 1.9	0.1 TO 0.9	0.0
1906-1910	77	75	2	0	0	0	0
1911-1915	79	58	19	2	0	0	0
1916-1920	84	22	32	30	0	0	0
1921-1925	89	12	17	48	12	0	0
1926-1930	92	3	10	30	37	12	0
1931-1935	93	0	6	17	28	42	0
1930	93	2	6	30	23	22	10
1931	93	2	6	23	28	22	12
1932	93	1	7	13	29	29	14
1933	93	0	7	18	19	33	16
1934	93	0	9	11	27	23	23
1935	93	0	7	15	18	29	24
1936	93	0	3	15	21	36	18
1937	93	0	1	13	26	26	27

#### LOWEST RECORD REACHED

For the seventy-eight cities for which complete data are available since 1910 there occurred 280 deaths from typhoid in 1936, which is the lowest of record (336 in 1936). The rate for this group of cities is for the third consecutive year less than 1.0. The rate for the ninety-three cities studied in 1937 is also below 1.0 (0.82) and considerably below the corresponding rate for 1936 (0.96). This statistical study again shows a downward trend in the death rate from typhoid in the large cities of the United States. Some small outbreaks have been reported but none of epidemic proportion. Routine vaccination of the population is not practiced except under flood conditions. However, in progressive communities vaccination is urged for contacts to cases and for persons who travel widely in countries where sanitary conditions are not of the best. Noteworthy is the improvement in the South, where the prevalence of typhoid in surrounding rural areas continues to handicap materially the large cities in attaining a lower death rate from typhoid.

TABLE 12

*Total typhoid rate for seventy-eight cities, 1910-1937\**

	POPULATION	TYPHOID DEATHS	TYPHOID DEATH RATE PER 100,000
1910	22,573,435	4,637	20.54
1911	23,211,341	3,950	17.02
1912	23,835,399	3,132	13.14
1913	24,457,989	3,285	13.43
1914	25,091,112	2,781	11.08
1915	25,713,346	2,434	9.47
1916	26,257,550	2,191	8.34
1917	26,865,408	2,016	7.50
1918	27,086,696†	1,824†	6.73
1919	27,735,083†	1,151†	4.15
1920	28,244,878	1,088	3.85
1921	28,859,062	1,141	3.95
1922	29,473,246	963	3.26
1923	30,087,430	950	3.16
1924	30,701,614	943	3.07
1925	31,315,598	1,079	3.44
1926	31,929,782	907	2.84
1927	32,543,966	648	1.99
1928	33,158,150	628	1.89
1929	33,772,334	537	1.59
1930	34,386,717	554	1.61
1931	35,137,915	563	1.60
1932	35,691,815	442	1.24
1933	35,691,815	423	1.18
1934	35,401,715	413	1.17
1935	35,401,715	348	0.98‡
1936	36,216,404	336	0.93§
1937	36,771,787	280	0.76¶

\* The following fifteen cities are omitted from this table because data for the full period are not available: Canton, Chattanooga, Dallas, Fort Wayne, Jacksonville, Knoxville, Long Beach, Miami, Oklahoma City, South Bend, Tampa, Tulsa, Utica, Wichita, Wilmington.

† Data for Fort Worth lacking.

‡ The rate for ninety-three cities in 1935 was 1.03 (total population 37,437,812, typhoid deaths 385), whereas in 1930 it was 1.64, and in 1933 and 1934 it was 1.24 and 1.25, respectively. The 1931-1935 average for the ninety-three cities is 1.31.

§ Rate for ninety-three cities in 1936 was 0.96 (total population 38,249,094, typhoid deaths 365).

¶ Rate for ninety-three cities in 1937 was 0.82 (total population 38,885,435, typhoid deaths 318).

Special Note.—Deaths for 1936 have been corrected, as Yonkers originally reported seven deaths and later corrected report to one death.

TABLE 13

*Total typhoid death rate per hundred thousand of population for ninety-three cities according to geographic divisions*

	POPULATION	TYPHOID DEATHS		TYPHOID DEATH RATES						
		1937	1936	1937	1936	1935	1931-1935	1926-1930	1925	
New England.....	2,640,933	12	11	0.45	0.42	0.49	0.70	1.31	2.48	
Middle Atlantic.....	13,426,805	68	74	0.51	0.56	0.55	0.80	1.40	2.97	
South Atlantic.....	2,609,531	51	40	1.96	1.55	2.58	2.70	4.50	7.01*	
East North Central.....	9,870,249	61	70	0.62	0.72	0.60	0.75	1.29†	2.32‡	
East South Central.....	1,330,969	28	43	2.10	3.35	3.94	4.81	8.31	13.00	
West North Central.....	2,778,245	21	22	0.76	0.79	0.85	1.24	1.83	3.43	
West South Central.....	2,084,616	49	79	2.34	3.99	3.82	5.36	7.32‡	13.08§	
Mountain and Pacific....	4,144,087	28	32	0.68	0.80	0.88	0.88	1.80	2.33	

\* Lacks data for Jacksonville and Miami.

† Data for South Bend for 1925-1929 are not available.

‡ Lacks data for Oklahoma City in 1926.

§ Lacks data for Oklahoma City.

## RECENT EXPERIENCES IN STERILIZATION OF DISTRIBUTION SYSTEMS

By B. A. POOLE

The literature dealing with water supply and its distribution contains numerous articles on the sterilization of new water mains, but, while this practice is commendable, it is far from universal. Spaulding (1) has pointed out that many of the larger water departments previous to 1925 were not sterilizing new mains. Eight Indiana public water supplies examined by the writer failed to meet Treasury Standards during the year 1937 because repairs and main extensions were not properly sterilized. Forty-two state sanitary engineers were recommending chlorination of new mains in 1937, but prior to this year their efforts lacked coördination and uniformity. Recommended minimum residuals varied from 0.2 to 100 p.p.m. while the recommended contact period varied from 15 minutes to 48 hours. Only twenty-two states required a laboratory check on effectiveness of chlorination.

The lack of any standardized procedure lead the Subcommittee on Water Works Distribution Systems of the American Water Works Association to incorporate in the Standard Specifications for Laying Cast-Iron Pipe, a section on sterilization. The committee fully realizes that the procedure outlined in its report is not the final word on the subject but believes it represents the soundest method yet advanced. Research and further experimentation will be necessary before a better specification is evolved.

It had been the practice of the Indiana State Board of Health to recommend that dry calcium hypochlorite or chlorinated lime be placed in each pipe joint in sufficient quantities to provide a chlorine concentration of 50 p.p.m. and to provide that upon completion of a job the new section be filled with water, allowed to stand over night,

---

A paper presented at the Illinois Section meeting at Decatur, Ill., April 5, 1938, and at the Indiana Section meeting Lafayette, Ind., April 8, 1938, by B. A. Poole, Ch. Eng., Indiana Bureau of Sanitary Engineering. The study was made in connection with the author's activity as a member of the committee on "Specifications for Laying Cast-Iron Pipe."

then flushed before the water was made available to consumers. Under this procedure it was found that calcium hypochlorite was often placed in the mains many weeks or even months before water was admitted for testing purposes. Our investigations revealed that the supposedly heavily chlorinated water which was being flushed from the hydrants often contained very little if any residual chlorine. This fact was attributed to the instability of chlorinated lime or calcium hypochlorite compounds and to the chlorine demand of the mud and trench water which was admitted during construction. As a result of these discoveries this practice is no longer recommended by the Indiana authorities. Calvert (2) has more recently found that the dry hypochlorite method of applying chlorine is not satisfactory even on short sections of pipe unless the water is admitted very slowly because the normal method of admitting water to a new section of main creates velocities so high that a chlorine "plug" is rapidly moved to the outermost extremities of the line. It is apparent, therefore, that little more than instantaneous contact throughout most of the length of pipe under consideration is effected.

Since the abandonment of dry hypochlorite or chlorinated lime applied directly to the mains, chlorine is now being applied to the mains through the elevated tank (if one exists) or by means of a portable chlorinator. Another advantage of this method is that chlorination is always preceded by very thorough flushing. Dosages of 40 to 50 p.p.m. are being used. The effectiveness of the distribution of chlorine throughout the pipe system is checked by ortho-tolidine tests and the chlorinated water is permitted to stand in the mains for a period of from 6 to 24 hours. Samples for test are not collected until all chlorinated water has been flushed from the pipe section under consideration.

During the past two and one-half years the Bureau of Sanitary Engineering of the Indiana State Board of Health has supervised the sterilization of nineteen separate distribution systems involving 413,000 ft. of pipe. Eleven of these projects have been listed in the following tabulation showing the strength of chlorine solution applied, the length of time the chlorinated water mixture was in contact with the pipe, and finally the summary of the bacteriological effectiveness of the treatment.

The samples shown in the table were collected from clean inside taps and transported to the central laboratory in Indianapolis immediately. Representative sampling points were selected

throughout the distribution system prior to the chlorination of the mains. The first outlet inside a building was usually chosen as the sampling point. In some instances chlorinated water was pulled through the service line as it was being admitted to the mains while in other instances the chlorinated water was merely drawn from the tap throughout the flushing period. Check samples gave no indication that contamination in the service line was a factor.

All laboratory work was done in accordance with the latest edition of "Standard Methods for the Examination of Water and Sewage." All presumptive tests were carried to completion. On some systems differentiation was made by the Methyl Red-Voges Proskauer method. All types of coliform organisms were found although aerogenes were predominant.

In many instances the systems referred to above were flushed twice between chlorine applications. The quality of the water at its source was checked during each sampling period, and the records indicate that it contained no coliform organisms in any 10 milliliter portion.

Municipalities I to IV used Universal pipe. Bell and spigot pipe was used in V to IX. Natural hemp was used in the bell and spigot joints of all of these mains except in Municipality V where tarred jute was employed. None of the hemp or jute had been sterilized prior to installation. All of these systems were new.

The distribution systems of Municipalities X and XI are old and were contaminated during the fall of 1937 by tank painting and repair work. Universal pipe was used in Municipality XI, whereas bell and spigot pipe with jute packing material (type not known) was used in Municipality X.

Municipality IV was one of the first examined. All of the earlier sterilization work was carried on by the contractor and it is possible that proper distribution of chlorine was not obtained and proper flushing not done. Later all work was carried on under technical supervision and very thorough examinations were made for possible sources of contamination; however, none could be found. The water supply is obtained from wells in a fissured rock formation. No unsatisfactory samples were produced by the wells, sampled at 15-minute intervals throughout a pumping period of several hours duration. Finally the system was rendered acceptable by the adoption of continuous chlorination. It was found necessary to maintain fairly high chlorine residuals during the period immediately following the time when the system was placed in service.

TABLE 1  
Sterilization of water mains

	TREATMENT			BACTERIOLOGICAL DATA		
	Date	Chlorine applied	Contact period	Date	10 ml. portions	
					No. taken	No. positive
		p.p.m.	hours			
Municipality I	10-12-36	10	12	10-13-36	15	13
"	11- 8-36	10	12	11-10-36	20	1
Municipality II	5-26-37	40	12	6- 3-37	70	21
"	6-24-37	40	24	6-25-37	35	8
"	7-15-37	40	24	7-19-37	40	2
Municipality III	6- 3-37	50	12	6-14-37	50	28
"				6-24-37*	15	15
"	6-24-37	35	12	6-25-37	30	2
Municipality IV	As laid	50	?	7-12-35	20	11
"	8- 6-35	100	12	8- 7-35	15	10
"				8-13-35	20	20
"	9-20-35	50	12	9-22-35	25	8
"	10- 1-35	60	12	10- 2-35	10	9
"				11- 5-35	55	22
"	11- 6-35	50	12	11- 9-35	75	28
"	11-19-35	50	12	11-21-35	40	25
Municipality V	6-25-37	50	24	6-28-37	50	4
"	7-19-37	50	24	7-21-37	55	0
Municipality VI	1- 8-37	25	12	1- 9-37	20	9
"	2- 5-37	50	12	2- 6-37	45	40
"	2-15-37	100	12	2-16-37	55	26
"	2-23-37	25	12	2-24-37	75	19
"	3- 8-37	50	12	3-10-37	60	29
"	3-12-37	25	12	3-15-37	50	5
"				3-22-38	25	4
Municipality VII	10-12-36	10	12	10-13-36	25	23
"	11- 1-36	10	12	11- 3-36	30	10
"	11-29-36	10	12	12- 1-36	30	6
"	12-20-36	10	12	12-22-36	10	0
Municipality VIII	As laid	50	?	8-12-36	30	25
"	8-19-36	2	24	8-21-36	30	22
"	9- 1-36	2	24	9- 3-36	75	45
"	9-12-36	10	12	9-14-36	40	19
"	9-29-36	10	12	10- 1-36	40	13
"	10-11-36	10	12	10-13-36	40	12
"	10-14-36	10	12	10-16-36	40	16
Municipality IX	11-27-36	5	24	11-28-36	15	7
"	12- 4-36	12	24	12- 5-36	15	0
"				3-30-37	20	2

TABLE 1—Concluded

	TREATMENT			BACTERIOLOGICAL DATA		
	Date	Chlorine applied	Contact period	Date	10 ml. portions	
					No. taken	No. positive
		<i>p.p.m.</i>	<i>hours</i>			
Municipality X	10- 4-37	35	12			
"	10- 5-37†	50	12	10- 6-37	30	12
"	11- 9-37	50	12	11-10-37	20	0
"				3-21-38	30	0
Municipality XI	1-15-38	50	8	1-31-38	30	10
"				3-21-38‡	25	5

\* Taken during flushing, prior to chlorination.

† Additional chlorine applied because residual was low.

‡ Flushed prior to sampling.

The results on Municipality V apparently confirm the findings of Kingsbury (3) and Spaulding (1) that tarred jute does not support bacterial life. However, strong chloro-phenolic tastes were evident throughout the system for months after it was placed in service and for this reason tarred jute should be barred from water mains.

It will be noted that a great deal more work was required to sterilize the systems containing hemp than was required by those containing no jointing material. Spaulding (1), Calvert (2), Kingsbury (3), White (4), and Gettrust (5) have all shown that most jute and hemp contains coliform organisms. It has also been shown that, even in sterile form, jute and hemp contain food for these organisms (1, 2, 3). Joint packing material was therefore undoubtedly responsible for the added work occasioned by repeated treatment on these systems.

Routine samples which have been collected from all of these distribution systems since acceptance have shown them to be free from coliform organisms with the exception of Municipalities VI and VIII. Municipality VI has been generally satisfactory but it is noteworthy that coliform organisms were found more than one year after acceptance. It is probable that the contamination introduced during construction is responsible for these results. Municipality VIII failed to meet Treasury Standards during the fiscal year of 1937 but some of the more recent unsatisfactory samples were taken from the pumping station. Therefore, it is impossible to definitely classify the source of contamination here.

Several writers have questioned the sanitary significance of the contamination which is invariably found in new pipe lines. The writer admits that the aerogenes type of the coliform organism is predominant in new systems but the writer is still of the opinion that the contamination must be taken seriously. Kingsbury has demonstrated that typhoid organisms multiplied 2,000 fold within ten days in jute packing material. There are no data to indicate that these organisms will not live indefinitely in hemp or jute. Wolman and Gorman (6) report one typhoid epidemic between 1920 and 1929 which was traceable to contamination that was introduced during main construction. Investigators of several other epidemics have concluded that the contamination of mains may have been responsible for the epidemic, but, because of lack of concrete evidence, have classed the outbreak as of undetermined origin. It is a well known fact that sewage may be admitted to a new pipe line during construction. Tank cleaning and repair, an item which has apparently been completely overlooked by many water superintendents, may also be instrumental in starting an epidemic. Therefore, the writer concludes that no water from new water works structures or underground piping should be made available to the consumers until laboratory determinations indicate that the water is safe for human consumption. The corollary of this conclusion is that sterilization of newly laid water mains should be a universal practice.

#### SUMMARY

In summarizing our experiences, the following conclusions may be drawn:

1. All new water mains are subject to contamination which is introduced during construction and consequently they should be sterilized.
2. Tank repairs also subject the entire water works distribution system to possibility of contamination and these structures should be sterilized.
3. Commercial jute and hemp packing material aggravates contamination and should be sterilized before being used for making joints.
4. Tarred jute is an unsatisfactory joint packing material because of the chlorophenolic tastes which are formed in the presence of chlorine and it should be rejected.
5. Chlorination and flushing will eventually free a new water main of contamination. However, the amount of work involved makes the

use of chlorine undesirable in certain systems and some new bacteriacide should be developed.

6. Sterilization of distribution systems with dry calcium hypochlorite or chlorinated lime is the least effective method now practiced.

#### REFERENCES

1. SPAULDING, CHARLES H. Contamination of Mains by Jute. *Am. J. Pub. Health*, **21**: 12; 1380 (1931).
2. CALVERT, C. K. Private communication.
3. ADAMS, GEORGE O., KINGSBURY, FRANCIS H. Experiences with Chlorinating New Water Mains. *J. N. E. W. W. A.*, **51**: 1; 60 (1937).
4. WHITE, GEORGE I. Jute Causes Trouble. *W. W. Eng.*, **85**: 24; 1420 (1932).
5. GETTRUST, JOHN S. Contamination of Water in a New Pipe Line by Jute and Hemp Packing. Twelfth Ann. Report, Ohio Conference on Water Purification (1932).
6. WOLMAN, ABEL, and GORMAN, A. E. Water-Borne Typhoid Fever Still a Menace. *Am. J. Pub. Health*, **21**: 2; 115 (1931).

Both experience and time have proved that properly designed and laid out distribution and service pipe lines give long years of efficient service. However, both distribution and service pipes are subject to corrosion which reduces their carrying capacity, and also to electrolysis which, more particularly in the case of steel pipe, frequently results in necessary replacement. A pipe in a cast-iron main, due to uneven settling, vibration, or other causes, often is a very serious matter.

Being informed, through the experience of himself and others, as to the desirable and undesirable features of water pipes in common use, the Chief Engineer of the Montreal Water Board began a search for a water main reliable in all respects. He became interested in the many good characteristics of the so-called Bourne System of pipe construction which had been developed and in use in France and Scotland for a number of years.

A paper presented at the Canadian Section meeting at Windsor, Canada, May 27, 1938, by Charles J. Des Balleis, Ch. Eng., Montreal Water Board, Montreal, Canada.

## REINFORCED CONCRETE PRESSURE PIPE FOR MONTREAL WATER WORKS

BY CHARLES J. DES BAILLETS

The average citizen and the business and professional men seldom think of the network of mains through which they receive their water supply, until they are personally inconvenienced in obtaining such supply, or witness, or read in the public press of a sudden break in a water main which flooded streets and cellars, destroyed pavements, interrupted traffic, and resulted in heavy financial damages and expensive repairs.

Not so the engineer and more particularly the water works engineer. He desires to know what kind of a pipe it was, how it was laid, what caused the break or made necessary a replacement, how could such a break or replacement have been prevented, and many other matters concerning water pressure mains. The water works engineer is therefore faced with great responsibility when he undertakes to design or select from manufacturers a water main suitable in all respects for both present and future service.

Both experience and time have proved that properly designed and laid cast-iron and steel pipe have given long years of efficient service. However, both cast-iron and steel pipe are subject to corrosion which reduces their carrying capacity, and also to electrolysis which, more particularly in the case of steel pipe, frequently results in necessary replacements. A break in a cast-iron main, due to uneven settling, vibration, or other causes, often is a very serious matter.

Being informed, through the experience of himself and others, as to the desirable and undesirable features of water pipes in common use, the Chief Engineer of the Montreal Water Board began a search for a water main suitable in all respects. He became interested in the many good characteristics of the so-called Bonna System of pipe construction which had been developed and in use in France and Scotland for a number of years.

---

A paper presented at the Canadian Section meeting at Windsor, Canada, March 23, 1938, by Charles J. Des Baillets, Ch. Eng., Montreal Water Board, Montreal, Canada.

About July, 1929, two lengths of this Bonna pipe, 10 inches in diameter, were purchased and received from France, and tested under the supervision of the Water Board. The results of these tests were so satisfactory that the Water Board was convinced that the Bonna System of pipe construction, with minor improvements in design and fabrication, would make possible a concrete pressure pipe with all the desirable and none of the undesirable characteristics of the cast-iron and steel pipes. Since this date, the use of this type of pressure pipe has become standard practice with the Montreal Water Board.

#### GENERAL DESCRIPTION

The Bonna reinforced concrete pressure pipe is made of three parts:

- (1) A central welded steel tube which makes the pipe impermeable and provides a part of the required strength in tension.
- (2) An inner lining of reinforced concrete, placed by the centrifugal process, which protects the metal and gives an arch effect to resist external pressure and the weight of water in the pipe.
- (3) A shell of concrete on the outside, placed by the aid of vibrators, and reinforced by spirals and longitudinal rods, which adds to the stiffness and strength of the pipe.

The relative sections of the steel plate and rods embedded in the concrete are proportioned to the diameter of the pipe and the pressures for which the pipe is designed.

As now manufactured, the joint is not only watertight but as strong as the pipe itself, as it is formed by constructing over each connection what is practically a duplicate of the pipe section. The joint can if desired be further strengthened by forming a bell and spigot joint, or the steel shell can be welded and thus made continuous.

#### BRIEF DESCRIPTION OF MANUFACTURE

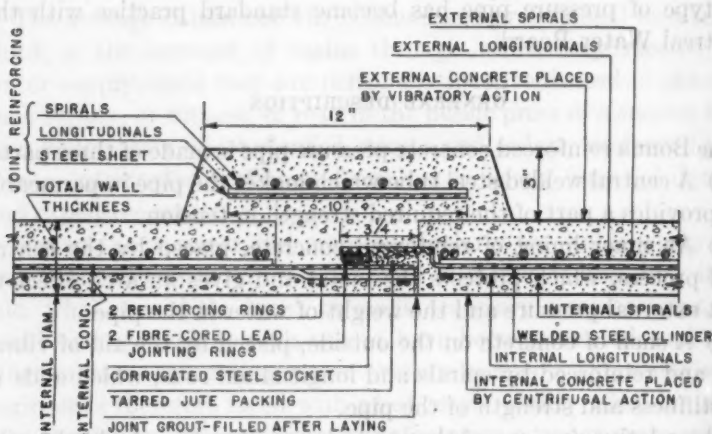
The steel shell is welded to form cylinders of proper length. The practice of hammering the weld while it is hot gives the deposited metal practically the same tensile strength and elasticity as the unwelded portions of the plate.

The tube is then lined with concrete by spinning and the centrifugal force produces a perfect contact between steel and concrete, and at the same time gives a very smooth and hard surface on the inside of the pipe. The speed of spinning the shell is 1,500 ft. per

min. at the start; this is increased to 2,500 to 3,000 ft. per min. at the end.

The mix is one part cement, one and three-quarter parts sand, and one and a quarter parts stone of  $\frac{1}{4}$ -inch size. The water-cement ratio is such as to give 3,500 lb. compressive strength in 28 days. The outer shell of reinforced concrete, when settled by the vibration

TYPICAL SECTION 24" CONCRETE PRESSURE PIPE - BONNA SYSTEM



SPECIFICATIONS

INTERNAL DIAMETER OF PIPE	24"	SIZE OF EXTERNAL SPIRALS	$\frac{3}{8}$ " DIAM.
PRESSURE HEAD	120 LB.	NO. " " " PER 10'	80
GAUGE OF STEEL CYLINDER	NO. 14	SIZE OF INTERNAL SPIRALS	$\frac{3}{16}$ " DIAM.
" " " SHEET	NO. 14	NO. " " " "	30
THICKNESS OF INTERNAL CONCRETE	$1\frac{1}{8}$ "	SIZE OF EXTERNAL LONG. BARS	$\frac{1}{4}$ " DIAM.
TOTAL WALL THICKNESS	3"	NO. " " " " "	16
WEIGHT PER FOOT	325 LB.	SIZE OF INTERNAL " "	$\frac{3}{16}$ " DIAM.
LAYING LENGTH	16'-6"	NO. " " " " "	16
		SIZE OF SPIRALS	$\frac{3}{8}$ " DIAM.
		NO. " " " PER COLLAR	7
		SIZE OF LONG. BARS	$\frac{1}{4}$ " DIAM.
		NO. " " " " PER COLLAR	18

method, is as well compacted as that of the inner lining by the spinning process.

The water-cement ratio for the outside shell is selected to give 4,500 lb. compressive strength in 28 days. The steel cylinder and reinforcing rods are of structural steel grade and are designed for tensile stresses of 11,500 lb. per sq. in. under normal conditions.

Concrete specials are of the same construction as the straight pipe, but, where impossible to use the spinning process, the inner lining is applied by hand. Both straight pipe and specials may be constructed with either spigot or bell ends or equipped with steel flanges to meet all requirements of pipe connections. The details of a typical pipe and joint are shown in the accompanying diagram.

The manufacturer of the pipes and specials is required to make shop tests of not less than 10 per cent of the pipes and specials to be furnished, under the hydrostatic working pressure for which the pipe or special is designed.

Pipe and specials passing such test and not damaged are considered acceptable for delivery. Pipe and specials damaged during the tests are rejected. Cracking of the inside lining or outside shell, leakage, or damp spots on outside shell are causes for rejection. Unsound pipes or specials showing segregation or soft spots in the concrete are also rejected. All hydrostatic tests are required to be made in an approved testing machine. All gauges are calibrated and the calibration certificate furnished to the engineer.

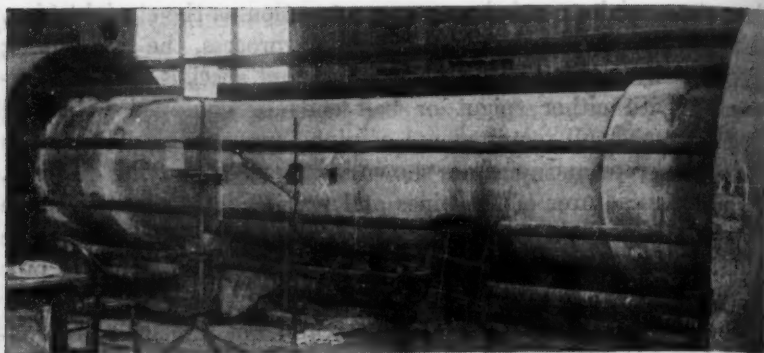
The hydrostatic tests of pipes or specials selected by the engineer are made by filling such pipe or special with water and pumping up until the specified pressure is reached. With the pump shut off, the indicated pressure must not drop during a period of 15 minutes.

The contractor is also required to test the joint he proposes to furnish. For such tests there is installed in the shop testing machine a standard length of pipe and two joints. In order to be acceptable, the joints must be absolutely water tight under twice the normal working pressure. Thus for the 36-inch pipe for a normal working pressure of 120 lb. per sq. in., the acceptable joint was required to withstand a pressure of 240 lb. per sq. in. and be absolutely water tight under this pressure.

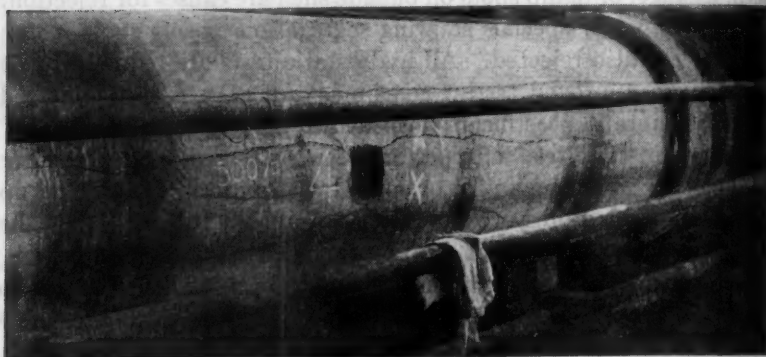
In addition to the above regular tests, the contractor from time to time was required to test pipes and specials to destruction, using for such tests hydrostatic pressures far in excess of the normal pressures for which the pipe and specials were designed.

The cost of the shop equipment for the tests and all regular tests of both pipe and specials is included in the unit prices quoted in the contract. For the tests to destruction, the contractor receives additional compensation.

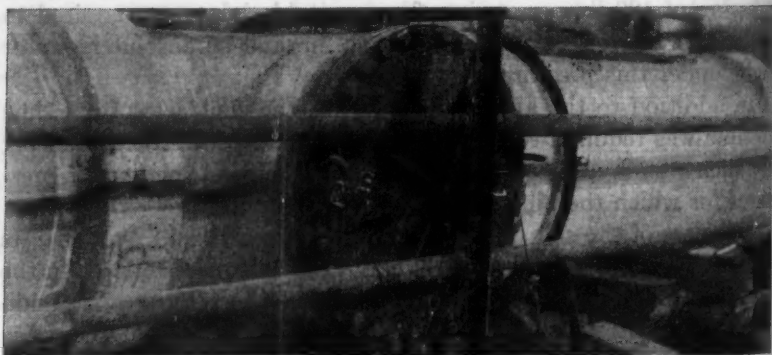
It is impossible, in a paper of this length, to describe fully the test apparatus and technical analysis of the results of the destructive



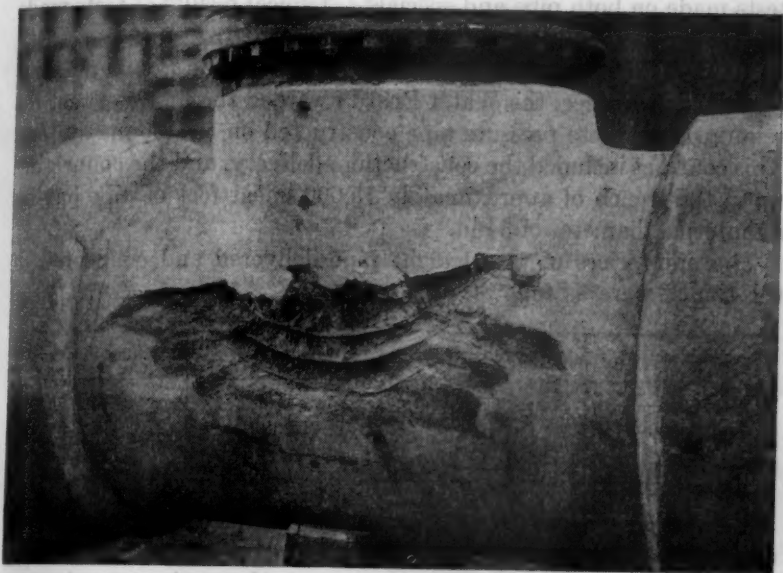
TEST OF 36-INCH REINFORCED CONCRETE PIPE



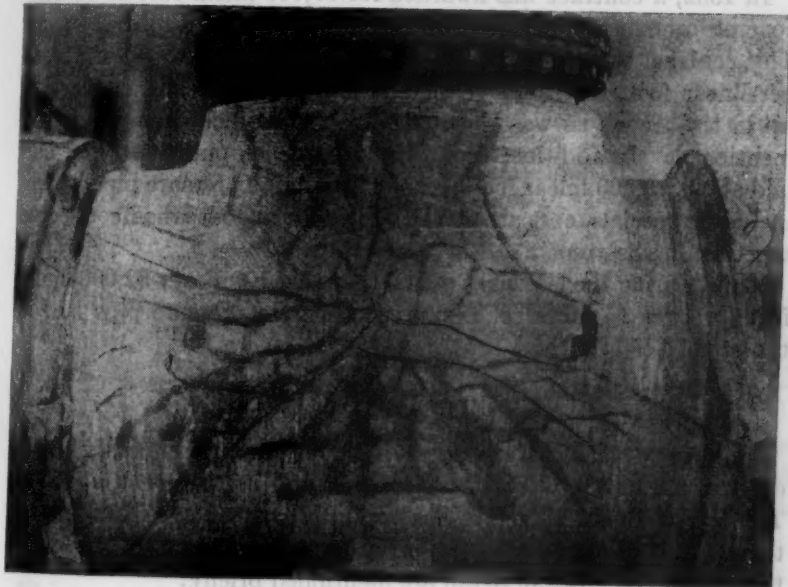
36-INCH PIPE UNDER PRESSURE OF 500 LB. PER SQ. IN.



DESTRUCTIVE TEST OF 36 BY 36-INCH TEE



36 BY 36-INCH TEE, AFTER TEST



36 BY 36-INCH TEE, AFTER TEST

tests made on both pipe and specials. Typical results of tests made are shown in table 1.

In July, 1930, about one year after the test of the Bonna pipe imported from France, the Water Board awarded the first contract for reinforced concrete pressure pipe constructed on the Bonna system. This contract included the construction, delivery, and the connecting up in the trench of approximately 15,000 linear feet of pipe having an internal diameter of 34 in.

The unit prices of the straight pipe delivered and connected in the trench were as follows:

LIN. FT.	GRADE	HEAD IN FEET	PRICE PER FT.
2,100	A	150	\$15.62
6,600	B	200	16.34
6,200	C	300	18.06

Reinforced concrete specials were also furnished under separate unit prices. These specials cost several times as much per linear foot as straight pipe and, if many are required, may increase the cost per linear foot of a completed main line from \$1.00 to \$2.00 per ft.

In 1932, a contract was awarded for 57,000 linear feet of 36-inch concrete pressure pipe for a working pressure of 120 lb. per sq. in. This contract was at the unit price for straight pipe alone of \$14.45 per linear foot, and did not include joint material and connecting up in the trench as was the case with the 34-inch pipe previously mentioned. In addition, the Water Board has purchased and had laid about 10,500 linear feet of 24-inch concrete pressure pipe which, including specials, cost about \$10.00 per linear foot when connected together in the trench.

Thus, during the last eight years, there has been over 82,000 linear feet (or over 15 miles) of reinforced concrete pressure pipe laid in the streets of Montreal.

#### PIPE LAYING

Failures or leaks in water pressure mains are too frequently due to carelessness in the work of pipe laying and backfilling the trench. The Water Board therefore has carefully written specifications for this work, and these specifications are rigidly adhered to. A few of the matters specified in detail are mentioned briefly:

- (1) Soft Foundations: Whenever the bottom of a trench is found

too soft or otherwise unsuitable to support the pipe, the contractor must excavate to such greater depth and construct such special foundations as the engineer shall direct.

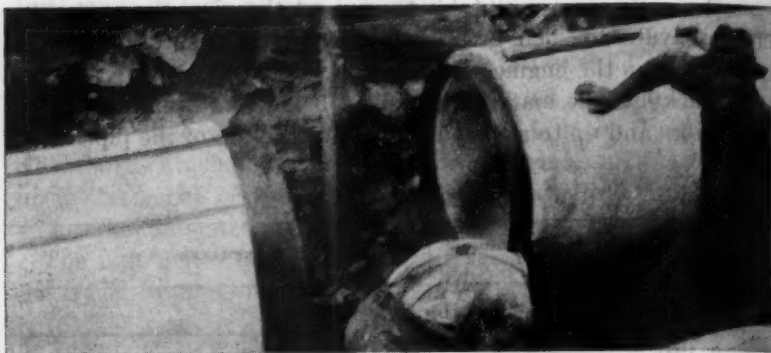
(2) Backfill: The material backfilled below and around the sides of the pipes and up to a level 18 in. above the top of the pipes is re-

TABLE 1

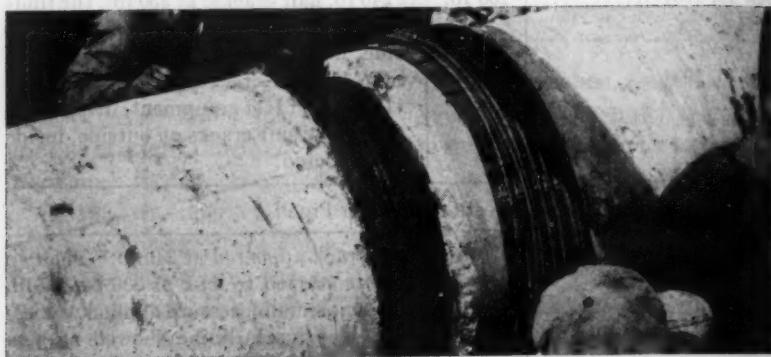
DATE	DESIGNED FOR	REMARKS
Tests on 34-inch Pipe		
Sept. 9, 1931.....	65 lb.	At 121 lb. slight fissuring.
Sept. 17, 1931.....	87 lb.	At 140 lb. first fissuring. Pump stopped working at 350 lb.
Oct. 15, 1931.....	130 lb.	At 240 lb. hair cracks; at 350 lb., the limit of test equipment, hair cracks on outside, inside not affected.
Oct. 15, 1931.....	130 lb.	At 220 lb. hair cracks; tested at 500 lb., the limit of test equipment, dripping at one joint, hair cracks on outside, inside not affected.
Tests on 36-inch Pipe		
Nov. 14, 1932.....	120 lb.	First crack appeared at 240 lb. The two joints started to leak at 330 to 340 lb. The maximum pressure applied was 420 lb. The inside lining showed no sign of cracks.
Dec. 29, 1932.....	120 lb.	First cracks appeared at 290 lb. The two joints started to leak at 330 lb. The maximum pressure applied was 450 lb. The inside lining was found undamaged.
Feb. 27, 1933.....	120 lb.	First cracks appeared at 370 lb. The two joints started to leak at 300 lb. The maximum pressure applied was 410 lb.

quired to be of earth or other fine material. The remainder of the trench backfill must be free of large stones and shall contain sufficient earth and fine material to permit of proper consolidation and prevent subsequent settlement.

Stone dust has been found to be most excellent material for backfill below and about the sides of the pipes. The backfill is consoli-



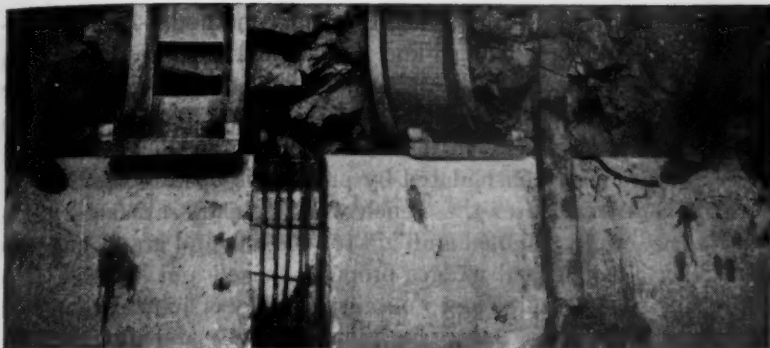
PLACING PIPE TO LINE AND GRADE



PLACING LEAD PACKING AT JOINTS



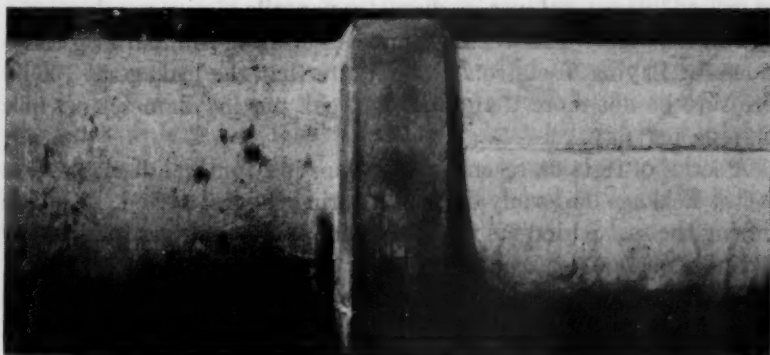
CAULKING LEADED JOINTS



JOINT REINFORCEMENT IN PLACE



FORMS IN PLACE FOR CONCRETING JOINT



THE COMPLETED JOINT

dated either by the "water" or "tamping" method. In the water method, the trench is flooded and the backfill is deposited in layers not exceeding 12 in. in depth, and well worked and deposited by water jet before the next layer is placed. In the tamping method, the backfill is deposited in layers not exceeding 6 in. in thickness. Each layer is thoroughly consolidated by pneumatic operated tampers.

(3) Pipe Work: After the trench work is made satisfactory, the pipes are carefully handled and laid to true line and grade, and supported by blocking and wedges properly spaced and bedded. The pipes must be spaced so as to obtain accuracy of joint spacing and insure uniformity of clearance both longitudinally and also for caulking space in a circumferential direction.

#### LEAKAGE TESTS

After sections of a pipe line have been connected, and before backfilling is done, the pipe line is given a test for leakage. A final test is given after the main is completed and backfilled.

The section to be tested is first isolated by means of line valves, bulk heads, or test heads. The main is inspected and thoroughly cleaned before the leakage test is started. The main is then filled with water and the water pressure is maintained as nearly as possible at the normal working pressure for which the pipe is designed. For the 36-inch concrete pipe, this was 120 lb. per sq. in. After the satisfactory completion of the final test, the main is cleaned and chlorinated before being placed in service.

Under the test pressure, the permissible leakage is required not to exceed 20 imp. gal. per in. diameter per mile of pipe per day.

The 1938 American Water Works Association Standard Specifications for Laying Cast-Iron Pipe require that the leakage at 100 lb. pressure be not more than 65.4 imp. gal. per in. diameter per mile of pipe per day.

A series of tests on recent installations in Montreal discloses these facts: Leakage uniformly decreases during the test period. Leakage during the test period averages less than 2 imp. gal. per in. diameter per mile of pipe per 24 hours.

This remarkably low leakage can only result from proficiency on the part of both designing engineer and manufacturer of the pipe, but also on extreme care in laying the pipe and making the joints in the field.

Some of the desirable features of this type of water main are the following:

- (1) The first cost of manufacturing and laying is not excessive.
- (2) The concrete pipe has a very smooth inner surface which results in a very low friction factor which, unlike steel or cast iron pipe, remains the same or increases after years of service.
- (3) The pipe and joints are watertight under pressure greatly in excess of the normal pressures for which they are designed and cannot "blow out."
- (4) The concrete pipe and specials do not collapse or rip apart under destructive pressures. Floods of water do not escape and cause excessive property damage because the steel tube and reinforced concrete shell successfully resist any tendency for the escape of large volumes of water at the time of failure.
- (5) The concrete pipe is not subject to electrolysis nor is it subject to deterioration from rust.
- (6) The thick shell of concrete is insurance against damage from sudden heavy blows from exterior sources.
- (7) For maintenance and changes in the system, the concrete pipe has its advantages. Sections may be cut out for their replacement by valves or specials with either flange, bell, or spigot joints as desired, and these new joints will be as smooth, strong, and watertight as the original pipe.

*Discussion by F. F. LONGLEY.\** The paper by Mr. Des Baillets is an interesting description of the application of one type of reinforced concrete pipe to pipe line problems of the city of Montreal. For many years past, each year has seen an increase in the use of reinforced concrete pipe for pressure pipe lines. Concrete and cement mortar have, of course, been used in the construction of water supply conduits in one form or another, dating back many centuries. It is not a matter of common knowledge, however, that concrete pipe lines, designed and built according to principles recognized today as sound and effective, have been built for approximately a half a century.

Concrete pipe is sometimes referred to as a "backyard" product. Anyone can make an inner and outer mould and insert a cage of steel reinforcing and fill the mould with concrete, thus making a pipe. To build a pipe line of reinforced concrete pipe, however, with joints

\*Vice-President, Lock Joint Pipe Co., Ampere, N. J.

that meet the severest requirements of the water works engineer, with strength and water-tightness suitable for high service pressures, and to make provision for branches, blowoffs, air valves, access man-holes, and all the special features of construction demanded in pipe line engineering, is quite another matter and is a far cry from the crude "backyard" product. Correct and ingenious design and highest quality workmanship are fundamentally necessary.

Reinforced concrete pressure pipe has come into existence and developed to its present point, in part at least, because it combines more of the desirable qualities sought by water works engineers, and eliminates more of the undesirable qualities than other types of pipe.

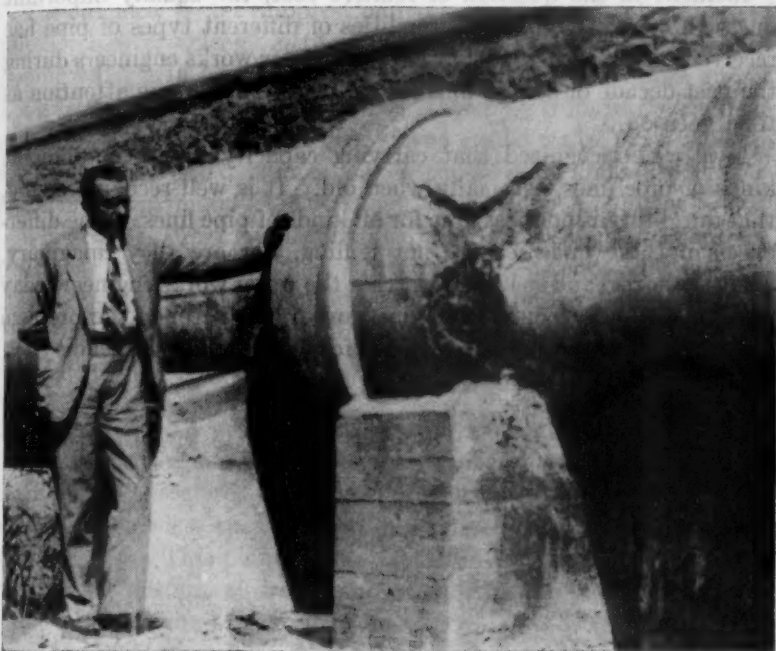
One of the qualities most sought after by water works engineers is high carrying capacity which remains high as the pipe continues for many years in service. Among the many erudite studies by Allen Hazen was one on flow of water in pipes, which he undertook in collaboration with Gardner S. Williams and which resulted in the two tools so commonly used by water works engineers, namely, the Williams and Hazen Hydraulic Tables and the Hazen-Williams Hydraulic Slide Rule. No one was better qualified to talk on this topic than Allen Hazen. During long years of association with Allen Hazen, the writer often heard him bewail the fact that a pipe line had to be built oversize when new because the carrying capacity would diminish; and further, that the future would bring developments in pipe line construction which would make this unnecessary.

His prophesy was correct. Pipe lines with inner surfaces of concrete have become firmly established in the picture. Being of concrete, there is no tuberculation, no accumulation of rusty scale, no element to encourage the growth of crenothrix. With high carrying capacity when new, the high carrying capacity is maintained as the pipe line continues in service, making it unnecessary to build oversize in anticipation of a diminishing coefficient.

Some of the illustrations in the author's paper show graphically what occurs when a test is carried to destruction. This is always an interesting guide in problems of design. The principle of the deacon's one-horse shay was a good one, strength and durability of all parts so nearly equal that no part gave way until the failure of all parts was imminent. The observations made from a test to destruction are an aid in bringing designs as far as feasible into line with this principle.

The accompanying photograph shows damage to the exterior sur-

face which occurred in quite a different way. In war-torn Spain, during one of the revolutionary disturbances of recent years, an effort was made to destroy a reinforced concrete pipe line exposed above the surface of the ground and crossing a small stream on bridge abutments. A charge of dynamite was set off against the outside of the pipe. The explosion scarred the outside surface of the pipe and exposed some of the reinforcing steel. The wall of the



EFFECT OF DYNAMITE BOMB PLACED BY SPANISH ANARCHISTS ON JULY 15, 1933 UNDER A 48-INCH, STEEL-CYLINDER, REINFORCED CONCRETE PIPE

The working pressure of the main is 170 lb.

pipe was not laid open nor was it even punctured by the explosion but appeared to retain its full strength and continued to serve as a satisfactory carrier of water.

A word regarding the cost of reinforced concrete pipe lines is in order. We frequently meet with the idea that a concrete pressure pipe line should be cheap. It is not easy and not safe to do much generalizing on the question of cost of this type of pipe line construction because it is affected by so many different factors. One

thing, however, can be said and that is that the modern, well-designed, well-built concrete pressure pipe line, to meet the exacting requirements of water works engineers of the United States and Canada, cannot be regarded as a cheap type of construction. Considering the several types of pipe lines commonly found in competitive bidding, and taking the field by and large, it is usually nip and tuck as to which type can win an award.

Incident to the question of relative cost, the equally important question of relative physical qualities of different types of pipe has received more and more attention from water works engineers during the past decade or so and bids fair to receive increasing attention as time goes on.

It is well recognized that carrying capacity differs in different kinds of pipe lines, especially when old. It is well recognized, too, that durability is not the same for all kinds of pipe lines. The differences in these qualities are not trifling, nor are they imaginary. They are so real and so important that the water works engineer today takes them into account as he does any other factor of the problem with a view to getting the best value for every dollar he spends.



The working pressure of the main is 100 lb. per sq. in. The pipe was not laid open nor was it ever painted by the explosion but appeared to retain its full strength and continued to serve as a satisfactory carrier of water. A word regarding the cost of reinforced concrete pipe is in order. We frequently meet with the idea that a concrete pressure pipe line should be cheap. It is not easy and not safe to be misled by this. On the question of cost of this type of pipe line construction because it is affected by so many different factors.

## A UNIQUE IRON REMOVAL PLANT

By PETER LEY

The Jamaica Water Supply Company supplies water to a part of the Borough of Queens in the City of New York and to some adjoining villages in Nassau County, all located on the western end of Long Island. The Company derives its supply from forty-one deep and shallow wells of the so-called Layne gravel walled type. These wells are distributed over an area of 40 square miles and serve a population of approximately 425,000.

Where the Company wells produce water of excessive iron content, treatment plants are installed. At two locations coke-tray aerators installed on top of steel standpipes have effectively reduced the iron. These installations involve double pumping and take up much space. The wells and house at Station No. 18-18A are located together with an elevated tank on a lot 8,100 square feet in area in a built-up residential section. A gravity coke aerator could not have been fitted to the small site and might have caused complaints of spray from the neighbors. Therefore, the Layne pressure filter for iron removal, which occupies less space than other types of deferrization plants, was installed. This plant is an adaptation to American practice of the Reisert system of iron removal already in successful use in French Indo-China as described in *Water Works Engineering*, January 22, 1936, page 67.

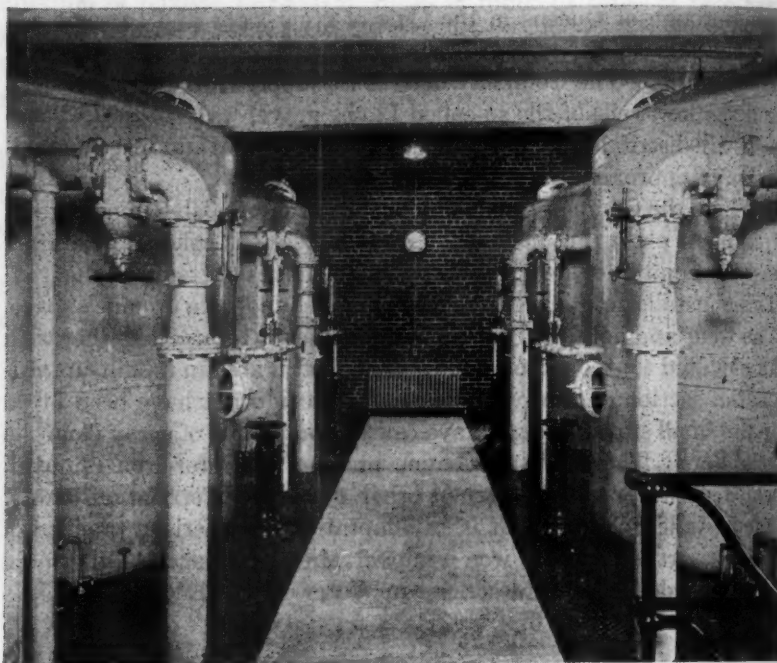
### SUPPLY AT STATION NO. 18-18A

The water supply at this station is taken from two gravel walled wells. Well No. 18 is a shallow well 16 in. in diameter and 248 ft. deep; Well No. 18A is a deep well 8 in. in diameter and 626 ft. deep. The wells have a specified combined capacity of 2.95 million gallons daily. Each well is equipped with a Layne and Bowler deep well turbine pump, driven by a 100 h-p., 220 volt, 3 phase, 60 cycle, slip ring motor. Formerly, these wells were connected directly to the

---

A paper presented at the New Orleans convention, April 27, 1938, by Peter Ley, Plant Supt., Jamaica Water Supply Co., Jamaica, N. Y.

distribution system and operated against a pressure of 40 lb. per sq. in. The piping connections are now modified so that water can be pumped either directly into the pressure filters against a 40 to 50 lb. pressure, or, if required in an emergency, the filter units can be by-passed and untreated water pumped into the system. Venturi tubes are installed in the pump discharge lines, the total pumpage as well as the rate of pumping being recorded on standard recording meters.



PRESSURE FILTERS FOR IRON REMOVAL, JAMAICA, N. Y.

#### PRESSURE FILTER TANKS

There are four vertical steel pressure filters each 10 ft. in internal diameter and 15 ft. 4 in. high, end to end. Welding is used throughout. The shell plates are  $19/32$  in. thick and the heads  $21/32$  in. thick. Six-inch flanged connections are welded on for the influent, effluent, and wash-waste pipes. The false bottom of the under-drain system is made up in sections for ease of installation and consists of steel plates  $\frac{1}{4}$  in. thick supported on 6-inch I-beams. These

plates are perforated with 1-inch holes on 6-inch centers. The filtering medium is supported over the holes by stainless steel wire cloth of 24 x 24 meshes per inch and of 0.020 in. diameter wire. The tanks are coated inside with clear Tropolite paint and on the exterior with two coats of Tropolite aluminum paint. Access into the tank is provided by a 12 x 16-inch manhole in the top and a similar manhole in the shell at about mid-height. Fig. 1 shows a sectional view of a filter tank.

The tanks are designed for operation at a rate of 5 gal. per sq. ft. per min. which is a high rate for American practice. This rate has been exceeded a number of times during summer peak demands. It is by reason of this high rate that the economy of area in this type of plant is possible. The normal rate for the four tanks is 2.0 m.g.d., which is the average yield of the wells. The rate of flow for each filter is indicated on Mercury flow gages.

#### FILTERING MEDIUM

The filter is located in the lower half of the tank. It consists of a layer 48 inches thick made up of a 50-50 mixture of Cape May sand with an effective size of 1.5 millimeters and a uniformity coefficient of 1.5, and of calcite which contains about 98 per cent pure calcium carbonate. The calcite is ground to an effective size of 1.5 mm. and weighs about 90 lb. per cu. ft. It has about the same specific gravity as the sand and therefore expands the same under washing conditions.

The upper portion of the tank is known as the aeration tower and contains a layer of lava 48 inches deep. This lava is brought from Montana. It functions in much the same way as coke does in a coke aerator. The raw water enters the top of the contact aerator and the compressed air for oxidation of the iron enters the bottom. The downward flowing water and the upward flowing air are brought into intimate contact by reason of the tortuous paths imposed by the jagged surfaces of the lava. The air is diffused from the 2-inch air manifold through  $\frac{3}{8}$ -inch copper laterals spaced 12 in. on centers, with  $\frac{5}{16}$ -inch orifices spaced 12 in. on centers. The lava is supported on 1 x 2-inch redwood strips with the 2-inch side vertical and spaced  $\frac{1}{4}$  in. apart.

#### AIR SUPPLY

Compressed air at the rate of 0.015 cu. ft. per gallon of water is required in the contact aerator. It is under a pressure a few pounds



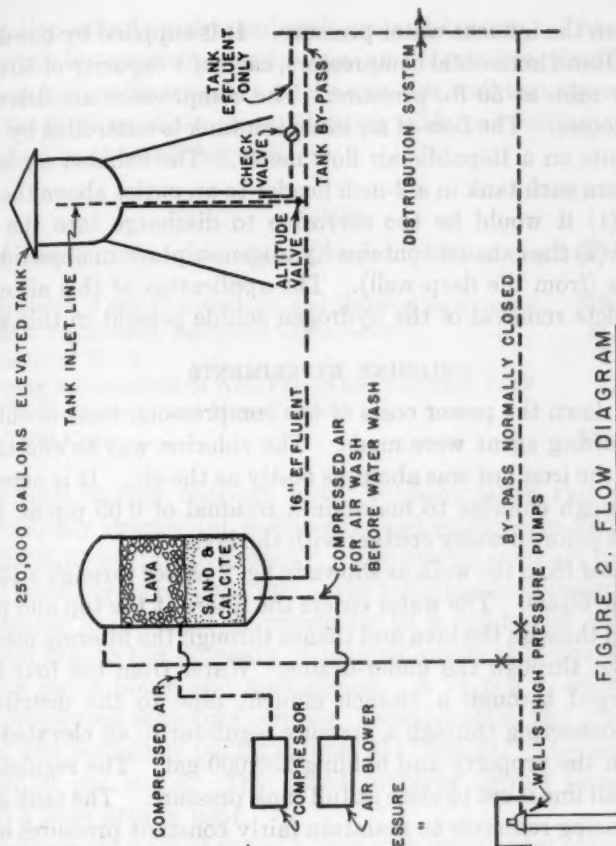


FIGURE 2. FLOW DIAGRAM

NO.	DEPTH	RATED CAPACITY	SIZE	MOTOR H.P.	PUMP
18	246'	1.44 M.G.D.	16"	100	12" TURB.
18A	632'	1.51 "	8"	100	15" "
TOTAL HEAD-PUMP 18 - 160 TO 180 FT.					
"	"	"	18"	170	190

## FILTRATION PLANT

CAPACITY - 2.0 M.G.D.  
 NUMBER OF TANKS - 4  
 TYPE - PRESSURE  
 RATE OF FILTRATION - 5 GAL. PER SQ. FT. PER MIN.  
 DIAM. OF TANKS - 10'  
 HEIGHT OF TANKS - 15'-4"  
 DEPTH OF SAND BED - 24"  
 " " CALCITE BED - 24"  
 " " LAVA BED - 48"  
 SIZE OF CALCITE & SAND - 1.5 MM.  
 AIR COMPRESSORS - 80 CU. FT./MIN. - 50 L.B. PRESSURE  
 BLOWER - 80 " " " 5 "

## ELEVATED TANK DATA

CAPACITY - 250,000 GALLONS  
 TANK DIAM. - 30'  
 TANK HEIGHT - 37.1'

## ELEVATIONS

GROUND + 126'  
 BASE OF FILTERS + 121'  
 TOP + 136.3'  
 TANK OVERFLOW + 226'

higher than the influent water pressure. It is supplied by one of two Ingersoll Rand horizontal compressors, each of a capacity of 80 cu. ft. of air per min. at 50 lb. pressure. The compressors are driven by 15 h-p. motors. The flow of air into each tank is controlled by valve adjustments on a Republic air flow meter. The exhaust air is conducted from each tank in a 2-inch header to an outlet above the roof, because (1) it would be too corrosive to discharge into the filter room and (2) the exhaust contains hydrogen sulphide in objectionable quantities (from the deep well). The application of this air causes the complete removal of the hydrogen sulfide present in this water.

#### CHLORINE EXPERIMENTS

To cut down the power costs of the compressors, tests of chlorine as an oxidizing agent were made. The chlorine was as effective in oxidizing the iron but was about as costly as the air. It is necessary to use enough chlorine to maintain a residual of 0.05 p.p.m. in the water just prior to water contact with the lava.

The water from the wells as shown in fig. 2 passes through a 16-inch pipe to the filters. The water enters the filters at the top and passes downward through the lava and thence through the filtering medium, passing out through the under-drains. Water from the four filters is discharged through a 16-inch effluent pipe to the distribution system, connecting through a pressure regulator to an elevated tank located on the property and holding 250,000 gal. The regulator on the tank fill line is set to close at full tank pressure. The tank serves as a balancing reservoir to maintain fairly constant pressures on the filter effluent which permits convenient and economical operation of the pressure filters.

The house has face brick walls, both exterior and interior, and a flat reinforced concrete roof supported on concrete-encased steel beams. The parapet is of brick surmounted with a concrete coping. All windows are fitted with steel sash and screens. The exterior door is metal clad. In addition to the filter room (which contains the four tanks, the compressor, and the blower) an office is provided on the same floor. The operating floor is made up of checkered-steel plates. A boiler room is located under the office. Oil is used for fuel. The boiler is of adequate capacity to heat both the filter house and the pumping station. Radiation is supplied by a combination of radiators and exposed piping. The filter gallery has no concrete floor; a 6-inch layer of  $\frac{3}{4}$ -inch bluestone on top of the porous sand

foundation affords a dry and well drained bottom. The tanks are supported by concrete foundations, and struts are placed between the foundations to transmit safely any side wall thrusts or the load from the footings of the elevated water tank, one footing of which is very close to the building wall.

#### COSTS

The construction costs of the 2 m.g.d. plant are as follows:

Structure, Tank Foundations, and Heating Equipment...	\$15,411.00
Filter Equipment, including Compressors.....	34,432.92
Electrical Work.....	1,061.47
Piping Adjustments to Well Pumps and Elevated Tank...	1,440.50
Office Equipment and Miscellaneous.....	250.55
Total Cost.....	\$52,597.04

These costs include contract costs, company labor and materials, and company charges for engineering and supervision and amounts to \$26,298.52 per m.g.d. capacity. The overall costs are higher than would normally be required due to the refinements in design and care in construction because of proximity to a residential community, and also due to the necessity of making substantial changes in the existing pump house and tank piping. A  $7\frac{1}{2}$  m.g.d. plant built in 1935, employing coke-tray aeration, sedimentation and gravity sand filters, and secondary pumping, cost \$171,206.28. This amounts to \$22,827.50 per m.g.d. This plant involves double pumping and covers a large area of land.

The filters are washed one at a time with wash water obtained from the effluent of the other filters. The filter is first agitated for a period of 5 min. with air supplied at 5 lb. pressure from a blower having a capacity of 80 cu. ft. per min. and then water-washed at the rate of 1,200 gal. per min. for a period of 5 min. Filters are washed once in 72 hours.

Operating results from May, 1937 to February, 1938 inclusive are shown in table 1. The operating costs per million gallons pumped into the filter are shown in table 2. These costs include electricity for pumps, compressor, blower, and lighting. They do not include any depreciation allowance or charges for interest or amortization.

Calcite is consumed both in the lime reaction and by washing out by the high velocity wash. The figures on calcite are based on the quantities required on two occasions to restore the full depth to the

TABLE 1  
Jamaica Water Supply Co. chemical analyses (p.p.m.)

Raw water sample composite of both wells

DATE OF TEST	SAMPLE	HARD- NESS	pH	ALKA- LINTY	FREE CO <sub>2</sub>	CHLO- RIDES	IRON	MANGA- NESE
June 1937	Raw	70	6.6	48	18.9	9.2	1.4	.14
	Filtered	80	6.9	65	11.4	10.0	.00	.08
July 1937	Raw	70	6.7	50	18.0	9.2	.95	.14
	Filtered	91	7.1	72	9.5	9.2	.00	.08
Aug. 1937	Raw	71	6.7	50	18.5	8.5	1.00	.14
	Filtered	94	7.3	75	9.0	8.4	.03	.08
Sept. 1937	Raw	79	6.7	52	18.5	8.1	1.10	.13
	Filtered	89	6.9	65	12.5	8.2	.02	.08
Oct. 1937	Raw	70	6.7	52	18.0	8.5	1.00	.06
	Filtered	89	7.1	72	11.0	8.5	.02	.06
Nov. 1937	Raw	70	6.7	52	19.5	8.1	1.00	.12
	Filtered	84	6.9	66	11.5	8.6	.03	.07
Dec. 1937	Raw	104	6.7	48	20.5	8.4	1.10	.13
	Filtered	120	6.9	64	12.0	8.4	.08	.07
Jan. 1938	Raw	66	6.7	48	20.5	8.3	1.20	.12
	Filtered	78	6.9	60	14.5	8.3	.04	.06
Feb. 1938	Raw	64	6.7	44	21.0	8.6	1.10	.13
	Filtered	83	6.9	68	13.5	8.6	.01	.02

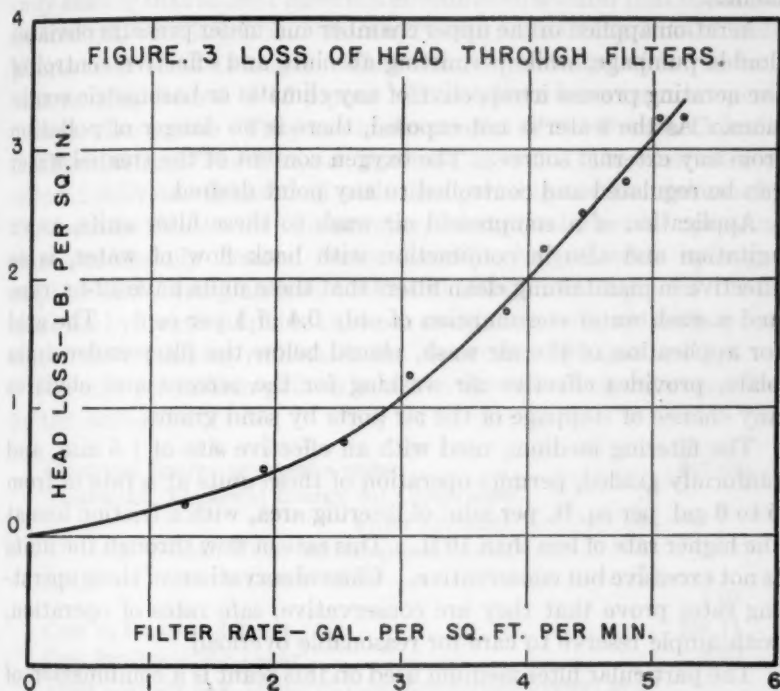
TABLE 2  
Operating data

MONTH	WATER TREATED	LABOR COSTS	ELEC. ENERGY COSTS	CALCITE CON- SUMED	CALCITE COST	COST PER M.G. PUMPED INTO SYSTEM
	mg.			tons		
May (1937).....	35.8	\$392.00	\$ 772.15	2.42	\$29.04	\$33.33
June.....	54.2	490.00	1,202.04	3.66	43.92	32.03
July.....	66.6	490.00	1,210.27	4.50	54.00	26.34
Aug.....	66.4	490.00	1,259.09	4.48	53.76	27.16
Sept.....	64.3	490.00	1,203.82	4.34	52.08	27.15
Oct.....	64.7	490.00	1,204.07	4.37	52.44	27.00
Nov.....	64.1	490.00	1,233.16	4.33	51.96	27.70
Dec.....	61.9	490.00	1,166.56	4.18	50.16	27.57
Jan. (1938).....	61.5	630.00	1,162.61	4.15	49.80	29.95
Feb.....	58.3	630.00	1,167.08	3.93	47.16	31.63

filters; the costs are figured on calcite at \$10.00 per ton plus \$2.00 a ton for hauling and placing.

The loss of head at various filter rates with clean filters is shown in fig. 3.

Twenty-four hour operation is required since the effluent is discharged directly into the distribution system and since it is necessary to control output in accordance with demands. The force consists of four men working 40 hr. per week, in 8-hour shifts; a relief man working 8 hr. per week at this station and the rest of his weekly time



at another station, so that the total weekly payroll is 168 man hours. Prior to January 1, 1938 the men were working 48 hr. each week.

The filter units were designed and erected in the spring of 1937 by the Layne-New York Co. under the personal direction of William I. Klein. The writer was in charge of the design and construction of the superstructure, heating, connecting piping, and electrical work. Sanborn and Bogert of New York City were consulting engineers for the Jamaica Water Supply Co.

*Discussion by WILLIAM I. KLEIN.\** Mr. Ley, in his paper, has presented a comprehensive description of this plant, the process employed, and its operating performance in removal of hydrogen sulphide, iron, and manganese. This process is unique in that a double treatment (aeration and filtration) is applied to the water within the same tank. The complete treatment is accomplished under pressure and without aid of any preliminary chemical treatment.

Aeration applied in the upper chamber and under pressure obviates double pumpage, while permitting absolute and effective control of the aerating process irrespective of any climatic or barometric conditions. As the water is not exposed, there is no danger of pollution from any external source. The oxygen content of the treated water can be regulated and controlled to any point desired.

Application of a compressed air wash to these filter units, as an agitation and also in conjunction with back flow of water, is so effective in maintaining clean filters that these units have 72-hr. runs and a wash water consumption of only 0.4 of 1 per cent. The grid for application of the air wash, placed below the filter under-drain plate, provides effective air washing for the screens and obviates any chance of stoppage of the air ports by sand grains.

The filtering medium, used with an effective size of 1.5 mm. and uniformly graded, permits operation of these units at a rate of from 5 to 6 gal. per sq. ft. per min. of filtering area, with a friction loss at the higher rate of less than 10 ft. This rate of flow through the units is not excessive but conservative. Close observations of these operating rates prove that they are conservative, safe rates of operation, with ample reserve to care for reasonable overload.

The particular filter medium used on this plant is a combination of silica sand and calcite. Successful use of a calcite means careful selection of the proper grade of material, cracking and grading to match the size of sand grains, and, in operation, care that the calcite is kept clean and free from surface coating of iron. Calcite covered with iron deposit is inert and not effective. Repeated examinations of the Jamaica plant filter medium disclose that all sand grains are coated with iron but that the calcite is clean and free from any inhibiting coat of deposited iron.

Calcite is employed as an aid in removal of iron, manganese, and carbon dioxide. Its use increases the alkalinity, raises the pH, and

\* Cons. Eng., East Orange, N. J.

aids materially in correction of corrosion troubles. Use of calcite in the filter unit (as part of the filtering medium) is an automatic operation, without supervision other than to recharge the tanks at stated periods, depending upon the quantity of calcite and its rate of consumption by the water.

I have been asked how much hydrogen sulphide and iron content of raw water this type of apparatus will successfully handle. I can only answer that so far I have not encountered a water that could not be treated. In Saigon and Cholon, French Indo-China, nine of these plants treat some 13 m.g.d. They handle raw water with iron content ranging from 5 to 15 p.p.m. These plants have been in operation for five years. They are under control of the French Colonial Authorities and The Pasteur Institute as well. The character of effluent delivered is identical with the operating results as shown by the Jamaica Plant. In this country, I have under actual operating tests successfully treated water heavily charged with hydrogen sulphide and having an iron content of from 20 to 25 p.p.m. In all cases the hydrogen sulphide has been completely removed to the point where the remaining residual is not detectable by taste or odor.

The cost per million gallons based on the operating data compiled by the author is:

Electrical Energy to procure water.....	\$18.08
Treatment: Electrical Energy Air Compressor.....	.70
"                    " Filter Friction.....	.44
Wash Water Consumption.....	.08
Calcite Consumption.....	.81
	2.03
Cost to Pump and Treat.....	\$20.11
Cost for Operating Labor.....	8.25
Total Cost per m.g. delivered into Distribution System at 50 lb. pressure.....	\$28.36

*Discussion by FRANK E. HALE.\** In the first place, I wish to congratulate Peter Ley for the part he has taken in the planning and adoption of this plant. It has accomplished its purpose successfully from the start. The aeration under pressure is similar to the Elgin process used for several years out West, except possibly for the use of the lava.

Mr. Ley has pointed out the benefits derived:

- (1) The small amount of space occupied by the plant.

\* Director of Laboratories, Mt. Prospect Laboratory, Brooklyn, N. Y.

(2) The high rate of filtration, 5 gal. per min. per sq.ft. against a 2 to 3 gal. usual rate, as well as a high factor of safety in that a much higher rate is efficient for short periods.

(3) Single pumping.

(4) No attention required for feed of chemicals.

(5) Capital cost not excessive.

Some of the disadvantages are:

(1) Calcite has only half the reaction value of lime hydrate for removal of carbon dioxide and also weighs more per unit value, hence is more expensive. This fact, however, may be offset by the cost of equipment and labor for handling lime hydrate. Hardness is increased twice as much by calcite as by lime hydrate per unit removal of carbon dioxide.

(2) Removal of free carbon dioxide is not complete, in fact is not efficient.

(3) Addition of dissolved oxygen is conducive to corrosion of metals.

On June 26, 1937, shortly after the plant started operation, we made inspections and analyses on the spot for dissolved oxygen, pH, and free carbon dioxide at each stage of the process, raw water, aerated water from each tank, and combined filtered water. Samples were also taken back to the Mt. Prospect Laboratory for a complete analysis. The following were the results at the plant:

SAMPLING POINT	DISSOLVED OXYGEN	pH	FREE CARBON DIOXIDE
	p.p.m.		p.p.m.
Combined raw.....	1.3	6.6—	18.9
Aerated (average four tanks).....	4.9	6.7	17.5
Combined filtered.....	5.4	6.9	11.4

The aeration introduced about 4 p.p.m. oxygen or less than half saturation value. The removal of free carbon dioxide by the aerators averaged only 1.4 p.p.m. or 7.5 per cent of the amount in the raw water. The calcite removed a further 6.1 p.p.m. or 32.3 per cent of the amount in the raw water, making a total of 40 per cent removal. Thus this method of removal of free carbon dioxide is very inefficient, other aeration methods alone producing 75 to 90 per cent removal. The chemical analyses at the laboratory indicated an increase in alkalinity of 17 p.p.m. and of total solids 16 p.p.m. The tanks

contained about 32 tons of calcite when full, and I prophesied that this would be entirely consumed in 256 days at the rate of indicated consumption, one grain per gallon or 142 lb. per million gallon. Mr. Ley's table covering nine months showed an average increase in hardness of 16 p.p.m., of alkalinity 18 p.p.m., average of the two, 17 p.p.m., also total removal of free carbon dioxide averaging 7.6 p.p.m., against our inspection value of 7.5 p.p.m., or 39 per cent removal against our 40 per cent. The consumption of calcite from May to December, inclusive, was 32 tons for 478 m.g. or 134 lb. per m.g. For the first five months consumption was 137 lb. per m.g. This would indicate that practically no calcite was lost by the high velocity wash of 15 gal. per sq.ft. per min.

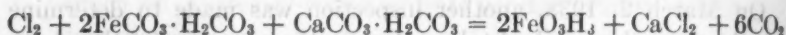
On March 2, 1938, another inspection was made to determine whether any changes had taken place in the operation of the plant. The same determinations were made of each unit and of combined raw and filtered waters. The average results were as follows:

SAMPLING POINT	DISSOLVED OXYGEN	pH	FREE CARBON DIOXIDE
	p.p.m.		p.p.m.
Combined raw.....	0.9	6.5	20.6
Aerated (average four tanks).....	3.0	6.7	16.1
Combined filtered.....	4.0	6.8+	11.5

The determinations in samples from the various units varied considerably. The averages are not greatly different from those previously obtained except that the removal of free carbon dioxide appeared about half and half divided between the aeration and the calcite, though the total removal was about the same. However, the alkalinity of the raw water was 46 p.p.m. and of the filtered water 67 p.p.m., an increase of 21 p.p.m., equivalent to 9.2 p.p.m., carbon dioxide against 9.1 p.p.m. total loss shown by the analyses. This would indicate that the calcite actually was responsible for the main loss of carbon dioxide, as in the previous tests. Total reduction in carbon dioxide was 44 per cent.

I am inclined to question the value of the aeration under pressure. It removes too little carbon dioxide. The introduction of air adds excess oxygen that may cause corrosion. The exact amount of oxidation of the iron may be accomplished by chlorination, maintaining a slight residual chlorine of 0.03 p.p.m. There would then be no excess oxygen to cause corrosion. It was at my suggestion that Mr.

Ley tried this at the plant for 24 hours and it was successful, as it has been before. We tried it at the Flushing plant with success, and Mr. Ley has found it successful at the No. 6 plant of the Jamaica Water Supply Co. Of course, chlorination will not reduce carbon dioxide but will slightly increase it to the extent of 2.36 times the iron content, or in the present instance about 2.1 p.p.m. As a matter of fact, the aeration also sets free two-thirds of this amount from the iron bicarbonate prior to its removal. So far as the iron is concerned, not more than 0.5 p.p.m. chlorine should be necessary at this plant. The carbon dioxide set free by chlorination is due to reaction with the ferrous bicarbonate and the fixation of the chlorine by the alkalinity. The reaction is expressed in the following formula:



That is, 3  $\text{CO}_2$  is produced by oxidation of 1  $\text{FeO}$ . Similarly, aeration sets free 2  $\text{CO}_2$  for each 1  $\text{FeO}$  oxidized.

There is sufficient dissolved oxygen in the water of well No. 18 to oxidize the iron in both wells in the plant, but when the plant was operated without aeration and without chlorination the iron was not removed.

The contact lava chamber would still be of advantage for reaction time in case the aeration were omitted.

The calcite may have a function apart from removal of carbon dioxide. It may assist in making possible the high rate of filtration through contact action. This is indicated by the low average iron content in the plant effluent with large effective size of sand and calcite, 1.5 mm., and high rate of filtration, 5 gal. per sq. ft. per min.

The final effluent shows in Mr. Ley's table average free carbon dioxide of 11.5 p.p.m., average pH 7.0 (6.9 to 7.3), average alkalinity 67 p.p.m. Considerable corrosion may be caused by such water on various materials, especially if dissolved oxygen be also present.

This type of plant undoubtedly has its place of usefulness. In the present instance I would operate it, if possible, by substituting chlorination for the aeration in order to limit corrosive action. This would also prevent any future growth of crenothrix or other iron bacteria, which is a common occurrence in iron removal filters.

## PRESSURE FILTERS FOR IRON REMOVAL

By R. S. CHARLES, JR.

During the years 1933, 1934, and 1935 the writer was associated with the development of a 30 m.g.d. water supply for the cities of Saigon and Cholon, in French Indo-China. The water supply was to be obtained from deep wells drilled into fresh-water strata underlying the alluvial plain on which the twin cities stand. Preliminary work in the region had indicated that the fresh ground water available was quite high in iron content. It was accordingly stipulated that the 30 m.g.d. supply should not only be bacteriologically pure but should also be satisfactory for domestic use, as determined from analyses by the Pasteur Institute.

French Indo-China is a tropical country, lying at the south-eastern tip of the continent of Asia, and, as with most tropical regions, abounds in vegetable growth. The cities of Saigon and Cholon are situated on tide-water, on the recently formed delta of the Mekong River. The superficial area of this delta contains a large proportion of a substance known as "laterite," which has the appearance and somewhat the composition of iron ore. The abundance of organic matter and the high iron content of the soil surface were conditions ideally suited for the development of a high iron content in the ground water. In confirmation of this premise, the first well constructed produced a water containing 15 p.p.m. iron and carrying 250 p.p.m. of carbon dioxide. The second and third wells were even worse, the former showing 56 p.p.m. iron and 204 p.p.m. carbon dioxide, the latter 44 p.p.m. iron and 325 p.p.m. carbon dioxide.

The projected water supply system provided for the spotting of the wells on the distribution system, pumping directly into the mains.

It was apparent that 50 p.p.m. of iron could not be removed by the elementary processes of aeration and filtration. Obviously the load carried by the water had to be reduced before it could be applied

---

A paper presented at the Canadian Section meeting at Windsor, Ontario, March 25, 1938, by R. S. Charles, Jr., Field Supt., International Water Supply, Ltd., London, Ontario. A part of this paper which duplicated information given by Peter Ley in the preceding paper has been omitted.

to filters. This implied flocculation by chemical means and sedimentation; therefore these three installations were necessarily of the conventional open, or gravity, type. The iron was successfully removed by the following steps:

- (1) Aeration.
- (2) Addition of hydrated lime by dry feed machine.
- (3) Mixing.
- (4) Addition of alum as coagulant.
- (5) Further mixing.
- (6) Sedimentation.
- (7) Application of chlorine as sterilization agent.
- (8) Filtration through rapid sand filters.

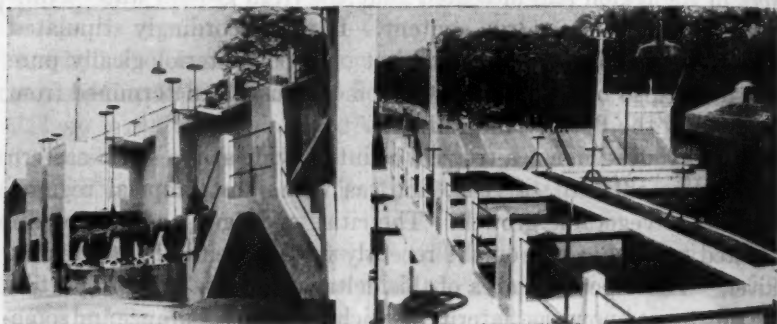


FIG. 1. GRAVITY IRON REMOVAL PLANT WITH CAPACITY OF 1.30 M.G.D.

Left: Pipe Gallery and Valves. Right: Filters and sedimentation basin from operating floor. Note portion of aerator at upper right.

The effluent produced by this treatment had an average iron content of 0.05 p.p.m. and the pH was raised from 5.2 to 7.1. The conventional methods were entirely successful in removing these large quantities of iron. In fig. 1 may be seen two views of one of these gravity plants.

In spite of such satisfactory results, however, certain serious disadvantages of these plants were brought to light when they were placed in operation. The open type of construction necessitated double pumping. The riffle plate aerators which were used gave poor efficiency of carbon dioxide removal thereby increasing the amount of chemicals required. Washing of the filters was unsatisfactory because of the high temperature of the ground water. But, in particular, it was found that the French authorities, and the Pasteur

Institute as well, had a definite aversion to the use of chlorine as a sterilization agent. Where it had to be used, as was the case with these three treatment plants, they would not tolerate the retention of the slightest residual in the treated water. (A new test, using methyl red as reagent, was devised to detect the presence of free chlorine.) Sterilization was particularly necessary, however, because of the open type of construction and the use of chemicals handled by natives.

Conditions were not helped by one native operator who imagined himself a concessionaire and made a considerable profit operating one of the sedimentation basins as a community swimming pool at so much a head. Even under normal conditions bacterial contamination was everywhere. In this tropical country the ground water temperature averaged about 88 degrees, and, although the water from the wells was sterile, bacteria were picked up in the aeration process and from the lime dosage. Bacteriological samples taken at different points in the plant showed that approximately 25 per cent of the count was acquired during aeration and the remainder appeared with the addition of lime. The effect of filtration was nullified by the fact that bacteria getting through the filters could continue to incubate in the clear well and, for that matter, in the mains.

#### DIFFICULTIES IN STERILIZATION

The sterilization process, rendered so necessary by these factors, was further complicated by the fact that the only source of free chlorine was chlorinated lime whose chlorine content varied from as low as 3 per cent to as high as 35 per cent. A prepared solution of hypochlorite deteriorated while being used, and the chlorine demand of the water varied considerably with the length of time the wells were pumped. The technical problem, to sterilize effectively and yet to show no residual in the treated water, was eventually solved, yet it remained far beyond the capabilities of the natives who were the only plant operators obtainable. Although the removal of iron had been successfully accomplished by these plants, it was obvious that they possessed inherent defects which it was desirable to avoid, if possible, in later construction.

Meanwhile, development of the wells which were to complete the 30 m.g.d. supply had continued, and it was gratifying to discover that all of the ground water was not so difficult to treat as the first three wells had indicated. Efforts were therefore concentrated on the

location and development of sources of ground water containing a minimum amount of iron. Simultaneously, experimental work on iron removal was continued in an effort to improve the processes.

Eventually, twenty-one wells, in addition to the three already equipped with treatment plants, were constructed, and the total water supply was brought to 30.5 m.g.d. Of these twenty-one wells, eleven contained so little iron as to require no treatment. The iron content of the other ten was materially reduced, the carbon dioxide varying from 43 to 180 p.p.m. and the iron ranging from a low of 0.5 p.p.m. to a high of 10.0 p.p.m.

The experimental work on iron removal had meanwhile made use of all of the conventional practices. Methods of aeration were materially improved, attaining much higher efficiency of carbon dioxide removal, but it remained impossible to secure satisfactory reduction of iron content by means of aeration and filtration alone. Months were spent in testing all of the usual chemicals as reagents, a measure of success being achieved with chlorinated lime. Ordinary hydrated lime, however, remained the most economical. A fourth gravity plant was eventually constructed, into which went all of the knowledge accumulated by experience with the first three plants, as well as the extensive experimental work that followed their construction.

#### PROBLEM MET BY CLOSED SYSTEM

No refinement of design, however, could alter the fact that the conventional treatment plant exposed the sterile well water to bacterial contamination from the atmosphere and from the chemicals used as reagents. The problem therefore resolved itself into one of devising a closed system which would protect the sterile well water from contamination from those two sources. Such a system would require elimination of atmospheric aeration and the use of chemicals. Aeration would obviously have to be accomplished by means of compressed air, and a new method of iron removal be developed.

These conclusions having been reached by independent investigation, it was discovered that a system of iron removal based on similar principles had already attained a certain measure of success in Europe. Investigation of the results obtained with that type of plant indicated that the design could be applied to the problem in Indo-China. Accordingly, a small-scale replica of the plant was shipped to Saigon, where it was set up on the various wells which

required treatment. Through this model plant was passed a definite proportion of the water to be treated, and, in this manner, it was possible to demonstrate in advance, without a great deal of expense, that the design was ideally suited to the conditions which were causing so much trouble. Thorough tests were conducted on each water to be treated, and the success of the program was thus assured in advance. It remained only to check these preliminary data with the performance of the full-scale apparatus.

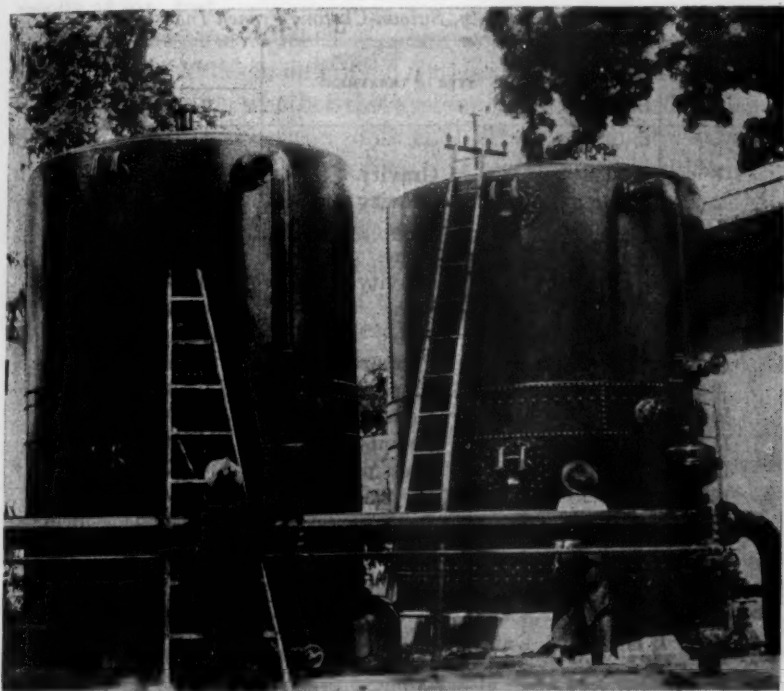


FIG. 2. PRESSURE PLANT WITH 1.5 M.G.D. CAPACITY

Steel plate and equipment for the first plant were shipped to Saigon. There the plates were rolled and welded into tanks and the plant was erected on the well which had the highest iron content, that of 10.0 p.p.m. When placed in operation and tested out, it was a complete success. Operating entirely under pressure, on the feeder main between the well pump and the distribution system, it required no double pumpage. All working parts were totally enclosed so that the sterile well water was not exposed to contamination from the

atmosphere, the use of chemicals was eliminated, and no chlorination was necessary. Operation was simple enough to be entrusted to the natives. And last, but not least, costs of treatment were materially reduced.

The answer to the problem in Indo-China had been found, and eight more of the plants were subsequently constructed, the nine having a total capacity of 13 m.g.d.

TABLE 1  
*Municipal water supply, Saigon-Cholon, French Indo-China*

NUMBER	CAPACITY	TYPE OF TREATMENT	P.P.M. IRON AS Fe	
			Raw	Treated
	<i>m.g.d.</i>			
1	1.24	Gravity	15.00	Trace
2	0.88	Gravity	56.00	0.15
3	0.88	None	0.10	0.10
4	0.76	None	0.20	0.20
5	1.30	Gravity	0.85	0.07
6	0.98	None	0.45	0.45
7	0.75	None	Trace	Trace
8	1.46	Pressure	1.05	Trace
9	1.46	Pressure	0.50	0.15
10	1.74	None	0.20	0.20
11	1.11	Gravity	44.00	Trace
12	1.50	Pressure	4.80	0.10
13	1.10	Pressure	1.80	0.15
14	1.40	Pressure	10.00	0.10
15	1.07	None	0.30	0.30
16	1.74	None	0.30	0.30
17	1.47	None	0.10	0.10
18	1.62	Pressure	3.80	0.30
19	1.52	None	0.10	0.10
20	0.94	None	0.15	0.15
21	1.16	None	0.30	0.30
22	2.00	Pressure	0.70	0.10
23	0.82	Pressure	0.80	0.10
24	1.61	Pressure	5.50	Trace

In the construction of these nine plants it was demonstrated that even in an area as small as that of a single large city variations in the characteristics of the ground water made careful tests in advance of construction of prime importance. This point cannot be over-emphasized.

In table 1 is given a tabulation of the twenty-four wells which were

constructed, showing the type of treatment used and the results obtained. It will be noted that the average iron content of the completed water supply was 0.133 p.p.m.

#### INDO-CHINA EXPERIENCE APPLIED IN AMERICA

There is nothing mysterious about this pressure system. It employs a combination of some of the familiar processes of iron removal, properly coordinated in a rationally designed plant to produce good results at low cost.

On the successful conclusion of the work of Indo-China, experiments were undertaken on ground waters in Canada and the United States to determine whether this system could be applied to conditions on the North American continent. The experimental work has confirmed the truth of the assertion that any iron removal plant can be properly designed only after thorough testing and operation of a pilot plant. In the city of London, Ontario, where the well water is hard and alkaline, fairly typical of ground water in the province, very little aeration or seasoning was required. At the Ridout Street plant 4 p.p.m. of iron was reduced to a trace using 2 cu. ft. of air per thousand gal. and a filtration rate of  $7\frac{1}{2}$  gal. per sq. ft. per min. At Newmarket, Ontario, good results were obtained with a minimum amount of air—less than could be measured accurately. The installation at Long Island, involving water low in iron and aggressive in character, resulted in a further improvement in the process, as has been recorded by Mr. Ley.

In the course of the past two years, two iron removal installations of the type described have been completed. In the case of the plant at Newmarket, Ontario, modification of the design was necessary owing to the presence of methane gas in the water. In spite of the difficulties occasioned by that circumstance, the plant has continued to reduce the iron content of the water from 2 p.p.m. to 0.25 p.p.m. in the effluent. The plant capacity is 300,000 imp. gal. per day. The other installation was the one described by Mr. Ley.

Certain features of this method of iron removal are interesting and results achieved with it have been remarkable. Although it is not intimated that the universal cure for every problem of iron removal has been found, the system discussed will correct the defects of many iron-bearing waters. There seems to be justification for the belief that this work represents a definite move forward on the road to the solution of the iron removal problem.

## AUTOMATIC VALVES

BY WILLIAM F. END

This paper is confined to automatic valve equipment utilized in the water works field. There is no reference to the many problems and automatic valve requirements which necessarily present themselves in the sewage, industrial, and power fields.

We may classify this automatic equipment as air intake, air relief, pressure reducing, pressure relief, surge and hammer, automatic check valves, combination valves, rate of flow controller, and automatic shut-off valves.

We shall break these classifications down, disregard the theory of design, and outline briefly what can be expected of the simple valves, their possibilities, and what capable supervisors and operators can accomplish with them. The subject as treated will justify the belief in efficiency, economy, and flexibility in the management of a water supply system.

Automatic valves for use in water works fields are divided into three general classes in accordance with the service for which they are designed. There are automatic valves (1) for control of air, (2) for control of flow, and (3) for control of pressure.

Under automatic valves for control of air are air intake and air release valves. The purpose of the air intake valve is to allow air to fill supply lines, particularly steel lines, to prevent collapsing when the water in these lines is removed. This valve is simple in design. It consists of a chamber in which may be assembled a float and lever arrangement, held closed under water pressure and open when pressure becomes zero or negative. The air relief valve differs from the air intake valve in that its size is smaller and its purpose to release air which may accumulate at high points in the line and reduce the carrying capacity of the supply line. This valve is made with a lever and float and it functions so as to close with water pres-

---

A paper presented at the New York Section meeting at Jamestown, N. Y., March 17, 1938, by William F. End, Civil Eng., Ross Valve Mfg. Co., Inc., Troy, N. Y.

sure and open with accumulation of air in the chamber. An assembly of a single unit to provide for both air intake and release is possible.

Automatic valves for control of flow are used principally in water filtration plants to control the rate of flow of water through filters. These valves are usually double seated and for the most part actuated by a diaphragm and lever with a weight. They operate in conjunction with a Venturi tube and register.

Automatic valves for control of heads and pressures include float, automatic check, emergency shut-off, pressure reducing, relief or back pressure, surge, altitude, and combination valves.

In this third classification, automatic valves for control of heads and pressures, we find a larger group, developed for the most part within the last ten to twenty-five years. The remarks to follow will cover nine types of valves in this classification, and, although somewhat brief in some instances, enough will have been said to identify each type.

All these valves may be controlled hydraulically and, in addition, equipped with secondary controls, such as electric solenoid or motor. The electric controls are generally used so that change in adjustment or control may be made from some remote point; and while a change in adjustment by hydraulic control can be made from a remote point, the maximum distance the pilot control can be economically located from the valve is about 1,200 ft.

In every instance in the design of automatic valves for control of heads and pressures, the superintendent and engineer must consider and provide for an assembly which will, under all operating conditions, insure closure of the valve when closure is necessary, and provide for balanced operating areas which will not induce hunting or surging.

#### REQUIREMENTS OF AN AUTOMATIC VALVE

A good automatic valve must meet the following requirements:

1. Must perform the duties irrespective of the varying and changing conditions.
2. Be capable of operation without inducing water hammer or surges.
3. Be capable of operation for flows from zero to maximum.
4. Be capable of easy adjustment.
5. Be constructed from material suitable for the service.

6. Be so designed as to permit of easy repair, inspection, test, and be of low maintenance costs.
7. Be simple—free from intricate mechanism.
8. Be compact and reliable.
9. Be capable of giving efficient, continuous, uninterrupted service without undue attention.

We shall now attempt to describe the automatic valves for control of heads and pressures.

*Float Valve.* As the name implies, this is a valve (1) actuated by a float assembled rigidly to an arm or lever which moves a piston in the valve; (2) assembled with a traveling float moving between two stops or limits; (3) assembled so that the float controls a pilot which in turn supplies the pressure or water power for moving the main valve stem; (4) assembled with a float and electric switch for making and breaking contact for current to motor.

The valve may be designed to operate as a throttling valve, semi-throttling, or to operate with the stem in two positions, namely, wide open and closed; and depending upon the hydraulic conditions. The float valve, as do all the automatic valves for control of heads and pressures, indirectly controls flow and directly controls head or elevation.

*Automatic Check Valve.* The simple check valve with vertical rising stem, ball or clapper, is classified as an automatic valve. In the more advanced design this valve is assembled with weight, lever and weight, or hydraulic cylinder operated by hydraulic pilots or in the more complex valve by these pilots and electric prime movers, such as solenoid or motor. The primary purpose of this valve is to prevent reversal of flow. The more intricate design incorporates another feature—closure without shock or hammer.

*Emergency Shut-off Valve.* The steady development and growth of cities has produced many problems resulting from expansion, and when a source of supply is 15 miles from the office of the operator (in addition to the many devices and means of knowing what is happening) the system of a large city with large supply mains demands other protection, and this in the form of emergency shut-off. The operator is concerned when a 48-inch line breaks and as a protection against resultant damage, the so-called emergency shut-off plays its part.

The average present day method for closing down a line valve requires considerable time, and when 24-inch or larger geared valves

are operated by hand, three or more men at the end of a bar have a very dizzy time, and in the interim a line may be washed out.

This type of valve may be operated (1) manually by one man by means of a hydraulic cylinder; (2) by electric motor attached to the valve and operated by a switch in the valve pit or from a remote point; (3) as an automatic valve controlled through a pilot and hydraulic cylinder, and when, and only when, the break is such that the rate of flow is greater than the combined rate for peak consumption and fire.

An operator should not fail to recognize the importance of this last statement, because the adjustment of the pilot is fixed and this pilot cannot differentiate between a drop in pressure due to fire flow and one resulting from a break in the main.

*Pressure Reducing Valve.* In its infancy this valve was a simple orifice, efficient only with a uniform rate of flow or when upstream pressures were constant. Necessity developed a device which would permit changing automatically the size of the orifice so that uniform pressure was possible irrespective of draft and changing pressures upstream of the valve. This I believe precisely defines what is known as the pressure reducing valve.

This valve accomplishes its purpose in changing one form of energy into another, either by increasing or decreasing velocities through the valve, thereby dissipating or destroying the head, and maintaining the desired downstream pressure. The change in velocity is automatically created through the reflection or communication of the downstream pressure to the control on the valve so that the orifice, seat, or opening in the valve may be restricted to such size as will permit the rate of flow necessary to develop the desired pressure. Usually the seat or orifice diameter is fixed and the restriction accomplished by a movable piston traveling into and out of the seat from zero opening or closure to maximum opening for the capacity of the line.

The stages in the development of this valve embrace in order the following: differential, spring loaded, lever and weight, and pilot operated.

The differential type of valve depends for reduction in pressure on the difference in piston area exposed to inlet and delivery pressure. For instance, with an area of one square foot exposed to the inlet or high pressure, and an area of two square feet to the delivery pressure, the movement of the main piston will be dependent on this

fixed ratio; or, in other words, the delivery pressure will always be one-half the inlet pressure, varying as the inlet pressure varies. This of course, precludes the possibility of maintaining a constant delivery pressure or any adjustment in delivery pressure over that obtainable through the designed piston ratio.

The defect in the purely differential design of valve, in so far as adjustment of delivery pressure irrespective of the inlet pressure is concerned, is overcome by the use of a spring loaded piston, or a weighted piston controlled by a lever and weight. Here again difficulties in operation cause, as with a spring loaded piston, the movement of the piston to be limited to the spring compression, which, for any appreciable movement, requires a considerable change in spring loading or change in delivery pressure. The spring loaded piston valve is, therefore, and should be, limited to small size and to small flows.

With the lever and weight control, the piston movement can be increased without the attendant variations in delivery pressure, but, in this type, the inertia of a heavy weight on a comparatively long lever arm, tends to cause pulsations in the main piston movement, resulting in excessive surges being started in the water mains.

The hydraulically operated piston valve, when properly designed, overcomes the objections found in the other three types. It allows a piston movement, when required, sufficient to pass the maximum discharge that can be delivered to and taken from it by a pipe line of like size as the valve.

The reducing valve will, of all types of automatic valves used in a water supply system, solve more perplexing problems and, in many cases, eliminate vast expenditures of money for expensive alterations and construction to accomplish the same result.

The pressure reducing valve will: (1) control and regulate pressures in gravity and pumping systems; (2) regulate the flow between reservoirs and zones of different pressures; (3) regulate fire flows between zones of unequal pressures; (4) regulate pressures in filter wash lines and aerator nozzles.

*Relief, Surge or Back Pressure Valve.* What has been said of the design and development of the reducing valve may in part be said of this valve. The essential difference lies only in the control, which in the relief valve is effected by the upstream rather than downstream pressure. In other words, the relief, surge, or back pressure valves as a group control the pressures from or on the inlet side of the valve.

In the smaller sizes up to 2 inches, these valves, assembled as spring loaded valves, are very effective for local surge and hammer disturbances; however, the engineer and superintendent who have had a wide experience with corrective measures with this type of valve prefer the pilot operated when volumes demand sizes 4 inches and larger.

How and where are these valves used? As a pressure lowering device for protection against excessive pressures and water hammer, much has been and can be written, and, while many designs for corrective measures have been submitted, the successful application can be traced to the good judgment and good management of a system.

*Relief Valve.* Relief is usually associated with a valve used to relieve excessive pressures not in the form of hammer and experienced in a system where for some reason there is possibility of elevating the gradient. The valve adjusted for a safe operating pressure may be located at a point in the system where waste water may be discharged to a stream, reservoir, or zone of lower pressure.

The so-called snifter is a relief valve in the smaller sizes,  $\frac{1}{4}$ -inch to  $1\frac{1}{2}$ -inch. The valve is the common garden variety of spring loaded stem, and its application a corrective measure in small lines and services where quick opening and closing valves, such as flushometer valves, create objectionable shock.

The sudden rise in pressure when starting and stopping pumps, particularly when the station is automatic and controlled by a pressure switch, provides another use for the relief valve. The valve is installed on the discharge of the pump either in a side outlet discharging to the atmosphere, or in a bypass around the pump to the suction.

*Back Pressure Valve.* Installation with a deep well pump is common, and the purpose of the valve is to give protection against overdrafting of the well. You may well imagine what might happen if discharge immediately adjacent to the pump should rupture or a break occur in the system. The drawdown in a well of this character is limited, and to safeguard this limit and prevent destruction of the well, the valve installed in the discharge maintains the safe back pressure irrespective of what may happen in the form of a break in the system.

*Surge Valves.* Surge and hammer is one of the major sources of worry for the superintendent. Higher pressures, quick opening and closing valves, together with pump characteristics contribute to

this annoyance. A cushioning device is necessary to iron out or decrease the peak of the hammer in the form of either a surge tank, air cushion, or valve.

A surge valve has some of the characteristics of the relief valve, differing essentially in the speed of piston travel. The surge valve is designed to open instantaneously at the moment the surge or hammer is reflected and to close slowly as the column of water comes to rest. Installation is made like that for a relief valve and in a pumping station is on the discharge side of the check valve.

*Altitude Valve.* The eighth of this group of automatic valves for control of heads and pressures is usually found near or adjacent to a tank, standpipe, reservoir, or sedimentation basin. This valve has at least the one important duty of preventing overflow of these different types of storage.

There is the single acting altitude valve in which, depending upon the operating pressure and hydraulic conditions within the system, the superintendent has the choice of a semi-throttling valve or a valve assembled so that the stem operates in two positions, open and closed. A semi-throttling valve develops a differential across the valve or a drop in pressure which may approach a fixed loss due to power required for supporting the stem which theoretically floats on the column of water and proportionally to the area of the power or operating chamber divided by the weight of the stem. Within limits this area, as well as the weight of the stem, can be fixed to produce a fixed differential of one pound and upwards.

If the hydraulic condition permits, this type of single acting semi-throttling valve may have three distinct and advantageous features: (1) For operation, external controls do not require waste of water to atmosphere. (2) In a gravity or pumping system, the valve will not induce surge or hammer. (3) When the tank is floating on the system with the pumping unit or station controlled automatically, better and closer adjustments on pump pressure switches are possible.

The second type of single acting altitude valve is one designed so that the stem assumes two positions, and the valve is either wide open or closed. Such an assembly is desirable when the static head at the inlet of the valve is no more than 2 to 10 feet greater than the static head of a full tank.

Under the head of Altitude Valve must be included the double acting valve, which, in addition to closing to prevent overflow of

the tank, will open to discharge from the tank to distribution and, if desirable, for a pre-determined distribution pressure. More complete remarks on this type of double acting valve will follow under the head of Combination Valves, the ninth and last of the automatic valves for control of heads and pressures.

**Combination Valves.** Thus far references have been confined to units capable only of one automatic and possibly two operations as in the case of the double acting altitude valve. The possibilities of control through automatic valves are not limited to a single function, and in an exaggerated case, a valve may be assembled with an outer control, providing for no less than five automatic operations.

As a combination valve the two or more duties imposed on such an assembly may be so established that control of the column of

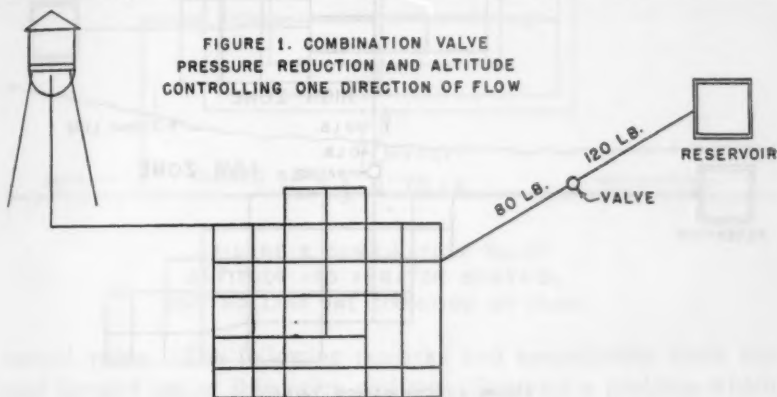


FIGURE 1. COMBINATION VALVE  
PRESSURE REDUCTION AND ALTITUDE  
CONTROLLING ONE DIRECTION OF FLOW

water is in one direction of flow and, if the problem requires, in two directions of flow through the valve.

The possibilities of an assembly with two or more controls are such that it seems advisable, in view of the lack of general information on the subject, to give some illustrative problems. The remainder of the paper will be devoted to examples of the subdivision types of the two major classifications of combination valves, namely, valves for control of flow in one direction and valves for control of flow in two directions.

#### CONTROL OF FLOW IN ONE DIRECTION

(1) As an example of a pressure reducing and altitude valve, let us take a small community with a low rate of flow, a source of supply at an elevation providing excessive heads in the system, and an

elevated tank floating on the line at the far end of the system (see fig. 1). The superintendent's problem is to provide for a reduction in pressure which must be constant, irrespective of the rate of flow, and at the same time this pressure or constant head must not exceed the elevation of the tank and thus avoid overflow of this tank. After a careful study, the superintendent selects the location for this dual purpose valve, and to make the problem and the illustration complete, let us assume that at this location the head at the inlet of the valve is 300 ft. and the head to be maintained at the outlet of the valve is 200 ft., the latter head providing for safe operating pressure

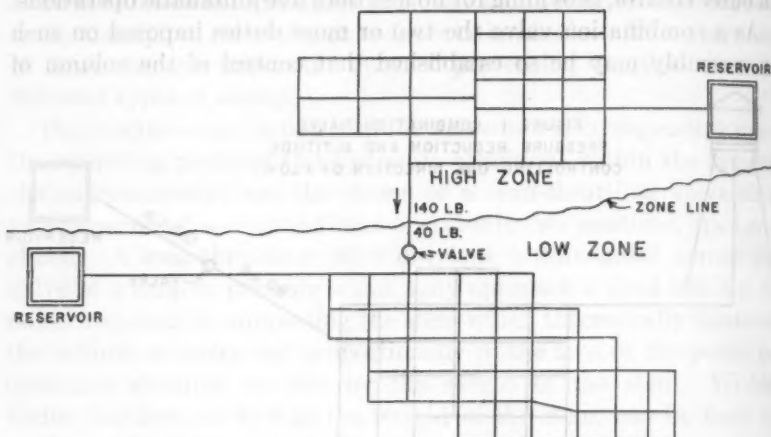


FIGURE 2. COMBINATION VALVE  
PRESSURE REDUCING AND RELIEF OR BACK PRESSURE  
CONTROLLING ONE DIRECTION OF FLOW

in the distribution, and the head which will prevent overflow of the tank.

(2) A pressure reducing and relief or back pressure valve might be used as shown in fig. 2. The need for such a valve may be easily described if we assume a system with two zones adjacent and separated by a closed gate. Pressure in the high zone at this point is 140 lb. and 40 lb. in the low. It is assumed that the high zone can afford to dissipate 25 lb. pressure and that the equivalent volume discharged into the low will provide the low zone with better operating pressures during peak load draft. The possibility of excessive pressure in the low zone imposes another provision and if specifications were written around a valve to fulfill both requirements, they would read somewhat as follows:

"The valve should automatically discharge from the high to the low zone insuring a back pressure for the high zone of not less than 140 lb. minus 25 lb. or 115 lb.; further, the valve must guard against the possibility of excessive pressure in the low zone as a pressure reducing valve, this pressure not to exceed 60 lb. at the valve."

As a back pressure or relief valve adjusted for 115 lb., it must be understood that the high zone has priority rights and in the event of fire in this zone, the valve would close or throttle should a high or fire rate of flow tend to lower the pressure below the 115 lb.

(3) Fig. 3 shows a possible use of an altitude and aerator nozzle

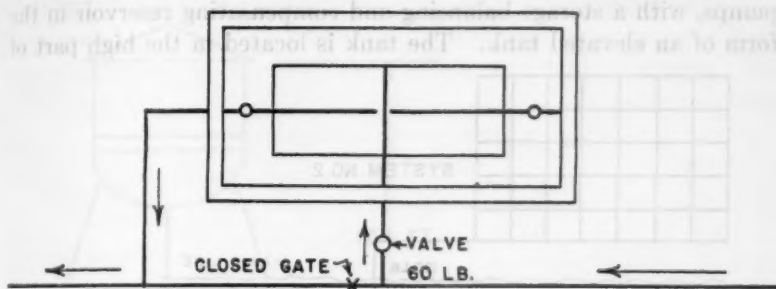


FIGURE 3. COMBINATION VALVE  
ALTITUDE AND AERATOR CONTROL  
CONTROLLING ONE DIRECTION OF FLOW

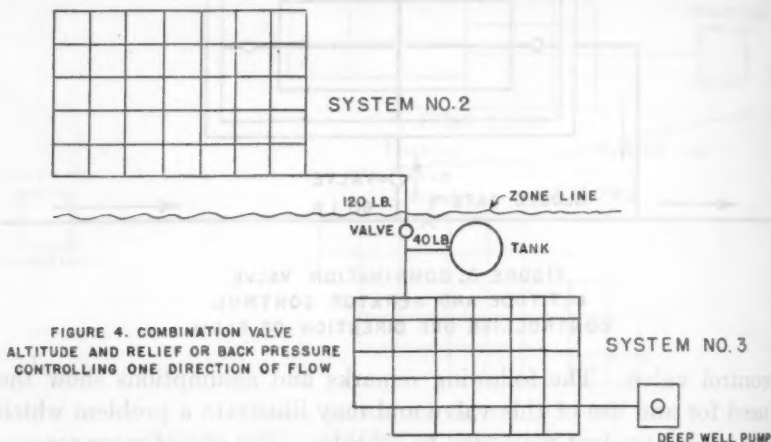
control valve. The following remarks and assumptions show the need for and use of this valve and may illustrate a problem which the superintendent may need to consider. For one or more reasons taste and odor may have made their appearance in the water supply, and prompt relief and remedy is demanded.

The remedy seems to be aeration. Because of the topography of the ground, the location of the reservoir, and the hydraulic conditions entering into the problem, the aeration basins are located so as to take water from the supply through the basins and around a closed gate valve in the supply line. At the point of takeoff the pressure averages 60 to 75 lb., and because of this pressure it becomes necessary to provide a valve such as an altitude valve, which will prevent overflow of the basins. In addition, the controls of this valve must provide for a head necessary and best suited for aeration and wind conditions as the water passes through the nozzles.

In this valve is incorporated a dual automatic control, maintain-

ing in the one direction of flow not only the head to prevent overflow of the aerator basins, but a head on the nozzles, and this head adjustable for prevailing climatic conditions.

(4) The use of the altitude and back pressure or relief valve combination is shown in fig. 4. The superintendent is operating a system of two zones, the one embracing the higher elevations of the community, the other being a low zone, each isolated from the other because of the topography, and the fact that pressures, reservoirs, and storage capacities make the two separate zones necessary. The upper zone is supplied by gravity, and the lower zone from deep well pumps, with a storage balancing and compensating reservoir in the form of an elevated tank. The tank is located in the high part of



the low zone, and adjacent to the higher zone. To make the problem complete so that an automatic valve of this character may be used, we shall further assume that the high zone can discharge during some periods of the day a volume of water into the low zone and tank, thereby saving some of the power costs for operating the pumps.

In addition to this automatic feature, the superintendent must specify that as a relief or back pressure valve, maintaining a constant back pressure in the high zone, the valve must also be equipped with a secondary pilot in the outer control to close this valve and prevent overflow, if and when the tank should fill.

#### CONTROL OF FLOW IN TWO DIRECTIONS

(1) Fig. 5 shows a possible use of the altitude and pressure reducing valve. The efficiency of many tanks erected and in service

could be improved if controlled by an automatic valve of this type. A striking example is that of a tank which, after being filled about 3 A.M., dumped the entire contents for the first peak load at 7 A.M. Thereafter it became impossible to refill or partially refill to an elevation which would efficiently serve the noon and evening peak loads.

A study discloses that the system during the peak loads will operate with a pressure at the base of the tank of 25 lb. Inasmuch as the tank is elevated so that the static at its base is 45 lb., it is planned to delay the discharge from the tank for the peak loads until the pressure in the distribution at the foot of the tank and at the inlet

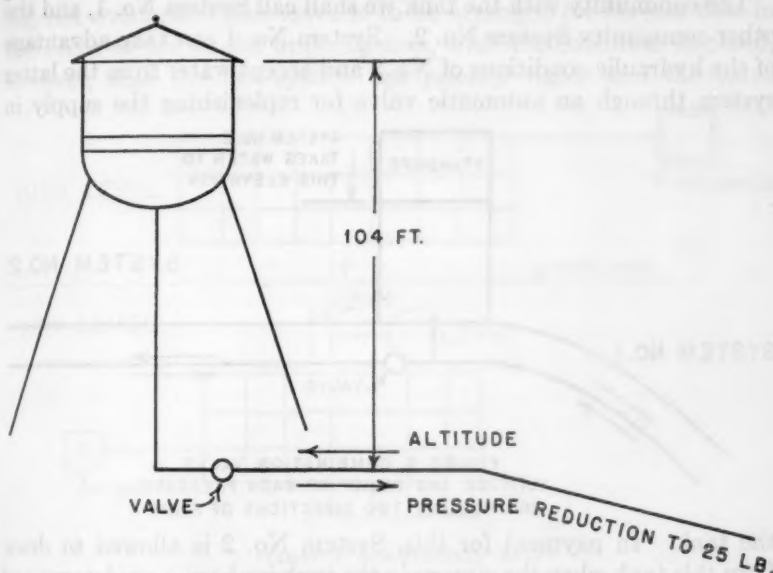


FIGURE 5. COMBINATION VALVE  
ALTITUDE AND PRESSURE REDUCING  
CONTROLLING TWO DIRECTIONS OF FLOW

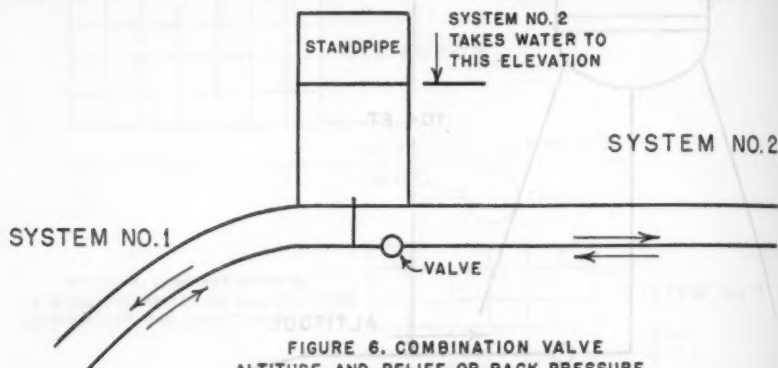
side of the closed altitude valve reaches 25 lb. An altitude valve equipped to prevent overflow of the tank, and at the same time open to discharge only for the pressure of 25 lb. at its inlet or distribution side, would provide efficient service, conserve the storage, prevent complete dumping of the tank on the first peak load so that between peak loads the tank could again be refilled, and the objectionable conditions as described would be avoided.

The valve to perform such a service would therefore be designated as an altitude valve which would permit flow into the tank, close to prevent overflow, delay opening for discharge to the distribution for

predetermined pressure drop in the distribution, thereby functioning and operating as a pressure reducing valve, and supplying makeup water from the tank to the distribution for a constant or nearly constant head throughout the distribution system.

(2) An altitude and relief, or back pressure valve, might be used in two communities or water supply systems adjacent, thus allowing them to strengthen each other. As an illustration of such a possibility, we shall assume as part of the system of one community, a standpipe erected a short distance from one of the lines of the adjacent system (see fig. 6).

The community with the tank we shall call System No. 1, and the other community System No. 2. System No. 1 can take advantage of the hydraulic conditions of No. 2 and accept water from the latter system through an automatic valve for replenishing the supply in



the tank. In payment for this, System No. 2 is allowed to draw from this tank when the storage in the tank is above a predetermined elevation. Below this elevation System No. 1 has priority rights, and water at this time cannot flow from the tank to System No. 2.

The valve for such operation would be specified as altitude and relief, or back pressure, and as an altitude valve, would take water from System No. 2, discharge into the tank and close when the water reached overflow. Return flow from the tank to System No. 2, reversal of flow through the valve, would take place if and when System No. 2 requires this flow for maintaining pressures. This System could draw water from the tank through the valve until such time that the supply in the tank would lower and reach the predetermined elevation for which the automatic valve would close to prevent further flow from the tank to the distribution of System No. 2.

(3) Fig. 7 shows the possible use of a pressure reducing and relief valve. The contour of the ground of this proposed water plant demands two closed systems, the upper system on the higher ground fed by gravity, the lower on the lower ground fed by deep well pumps. In a cross-over between the two systems the automatic valve is installed and so equipped that the higher system may discharge into the low at a predetermined and reduced pressure, operating as would a pressure reducing valve.

Because of a tank floating on the line in the low system, the adjustment for flow from the high to the low must be such that this tank will not overflow. The valve is to be arranged for reverse flow in the event of fire in the upper system, with the condition imposed, however, that the low system has priority rights and the valve

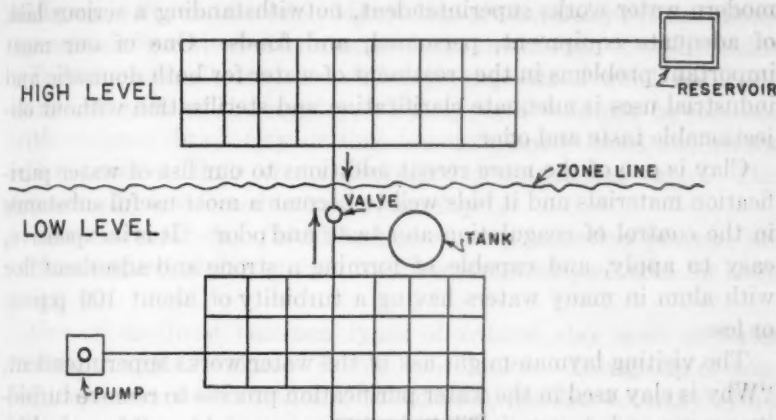


FIGURE 7. COMBINATION VALVE  
PRESSURE REDUCING AND RELIEF  
CONTROLLING TWO DIRECTIONS OF FLOW

adjusted for back pressure so as to prevent overdrafting of this low system.

Any of the above assemblies might have incorporated one or two more automatic duties and the pilots responsible could be hydraulically or electrically operated.

In the foregoing an attempt has been made to illustrate the possibilities of revamping and valving systems, so that wherever possible these systems may be operated with greater efficiency. There are many more combination assemblies which might be listed. This paper will terminate, however, by stating that the use of combination automatic valves will increase, and in their development and application, the superintendent, operator, and manufacturer will all play an important part.

## THE USE OF CLAY IN COAGULATION AND TASTE AND ODOR CONTROL

BY PAUL WEIR

During the past few years the public has become more and more quality conscious and cost conscious, not only concerning the production of foods, clothing, and machinery, but also, concerning the type of water furnished by their local department.

This condition has been coped with, to a large degree, by the modern water works superintendent, notwithstanding a serious lack of adequate equipment, personnel, and funds. One of our most important problems in the treatment of water for both domestic and industrial uses is adequate clarification and sterilization without objectionable taste and odor.

Clay is one of the more recent additions to our list of water purification materials and it bids well to become a most useful substance in the control of coagulation and taste and odor. It is inexpensive, easy to apply, and capable of forming a strong and adsorbent floc with alum in many waters having a turbidity of about 100 p.p.m. or less.

The visiting layman might ask of the water works superintendent, "Why is clay used in the water purification process to remove turbidity or suspended material?" A similar query might well be asked by any casual visitor at many of our water softening plants where lime is used in the process of water softening to reduce the lime salts of hardness.

The addition of bleaching or adsorbent clay to many water purification processes brings about a coalescing effect between the original suspended particles with solutions of alum. This results in the formation of a dense jell-like floc that settles rapidly, sweeping down suspended materials (hydrous aluminum-oxide) into the sludge area of the sedimentation basin. Thus the relatively clear supernatant water is permitted to flow to the filters for final clarification.

---

A paper presented at the New Orleans convention, April 27, 1938, by Paul Weir, Supt. Filtration, Atlanta Water Works, Atlanta, Ga.

Application of clay in the process of water purification may accomplish one or more of four essential functions in many of our treatment plants. These are: (1) A rapid settling of floc is frequently attained in conjunction with regular coagulants (widens pH-coagulation range). (2) Certain contributing substances to taste and odor (especially those due to oils, etc.) may be reduced or entirely eliminated. (3) Coloring matter imparted to water from vegetable sources is appreciably reduced, especially when used with alum coagulation. (4) Clay has been found to exert certain zeolitic effects on many hard waters.

We might refer to clays as certain earthy rocks containing varying amounts of hydrous aluminum silicates whose dominant property is that of plasticity when wet. Clays are usually porous, fine grained, and gray to brown in color. Many clays are naturally active. Some are artificially activated by means of acid treatment. Our discussion will deal principally with natural clays, deposits of which are found in various parts of the country. This group should not be confused with ordinary brick clay or that found in many fields and rivers, which possesses little or no adsorptive or coagulating value. This type usually is referred to as surface clay.

Many natural clays, used in the water purification process, are surfaced mined, dried, ground to a fine size, and packaged for shipment.

One of the most common types of natural clay used in water treatment might be classed as montmorillonite. This group of mineral clays may be divided into two classes, familiar to many of us, fuller's earth and bentonite clay. Fuller's earth is known to the oil trade as bleaching clay and to the water works superintendent as adsorbent clay. These clays possess many similar characteristics. Slight differences in composition, however, may greatly affect their function and value in water treatment.

Fuller's earth is used primarily as a floc builder, in that it adds toughness and weight to the floc particles. It accelerates coagulation, enmeshing colloidal suspended materials and bacteria into jelly-like conglomerates that settle rapidly. In many instances this superior floc formation has materially reduced taste and odor substances at the outset of the purification process; thus, the possibility of subsequent intensification is substantially reduced as the process continues.

Bentonite may be used advantageously as a coagulant in waters

having a relatively high hardness. It is especially effective as a coagulant in the presence of magnesium sulphate. It is evident, therefore, that each clay performs a definite function, according to the character of the water treated.

Both of these clays have an isoelectric point of about 9.2. Their colloidal silicates are negatively charged and are affected by electrolytes in water. Geologists say they are petrographically similar but are different in certain physical properties. Each possesses an amorphous colloidal structure with appreciable surface area which is capable of adsorption. The ability of clay, especially bentonite, to swell in water is said to be due to the expanding of its lattice-like structures by capillary pressure pushing apart the stable film around each particle. This ability of clays to swell in water may increase their volume from 5 to 20 per cent.

Dr. Edward M. Slocum (1), Research Chemist of the General Reduction Co., Macon, Ga., was an early advocate of the use of clay in water purification. Dr. Slocum has had international experience with clay in the oil and perfume industries. His continued interest and suggestions have been responsible, to a large extent, for the present use of clay in water purification.

One of the first successful applications of clay in water purification was made by R. I. Dodd (2), Chemist, Chester Water Service Co., Chester, Pa. He found that the application of clay at the intake well, prior to the application of alum in the mixing chamber, successfully reduced troublesome oily trade waste odors in the water. Putrefaction of organic matter in the sedimentation basin was noticeably reduced. Cold weather breaking up of the floc was also overcome by the formation of a stronger and more tenacious precipitate. Approximately 43 lb. of clay, costing about 35¢ per million gallons, was used at Chester.

Norcom (3), reports, after considerable investigation, that the use of clay in the treatment of Delaware River water effectively produced a more palatable water than formerly and at a nominal cost. The Delaware River water carries a considerable amount of trade waste which frequently causes pronounced taste and odor. Most of Norcom's work was carried out at the Chester, Pa. Plant.

Carl R. Alexander (4), Superintendent of Water Works, Rome, Ga., reports some very interesting data on the use of clay at an industrial rayon manufacturing plant. This plant derives its supply from the Oostanaula River. The turbidity of this water varies from 20 to

2,000 p.p.m. It is essential that filtered water used in the manufacture of rayon not exceed 0.1 p.p.m. turbidity. Many different combinations of coagulants were used in an endeavor to attain the desired results. Before clay was used in coagulation, it was practically impossible to obtain a filter effluent of less than 0.4 to 0.15 p.p.m. The application of 40 to 60 lb. of clay, with alum, not only produced a larger floc which settled more quickly, but also reduced the turbidity of the filtered water to 0.05 p.p.m. This combination of clay and alum produced a water of superior quality and at the same time reduced the cost of chemical application.

John R. Baylis (5), Physical Chemist, Chicago, Ill., has tested a number of different types of clay in the laboratory of the Chicago Experimental Water Treatment Plant. He concludes that clays are of assistance in the formation of a heavy and rapidly settling floc on Lake Michigan water. However, his results in taste and odor control did not indicate an appreciable reduction.

Odell W. Gray (6), Chemist, Water Softening Plant, Thomasville, Ga., reports that when clay was used as the principal coagulant in water softening, the hardness of the finished water was substantially reduced. The increased efficiency of coagulation produced a superior finished water, both chemically and bacteriologically. Filter runs increased from 40 to 150 hours between washings. The application of clay was responsible for a 10 per cent chemical saving.

H. L. Olin (7-8), Professor of Chemical Engineering, University of Iowa, and collaborators J. V. Gauler and H. W. Peterson, have published two outstanding treatises on "The Use of Bentonite Clays in Water Purification." Professor Olin has spared neither time nor detail in the compilation and execution of this invaluable research project. The reports indicate that certain alkali bentonite clays (Utah and Wyoming) readily coagulate in the presence of dissolved mineral matter to form a heavy gelatinous floc which filters rapidly, giving a sparkling clear finished water. These clays are slightly zeolitic. They have little effect in reducing vegetable coloring matter in water. Utah bentonite clays swell about eleven times their original size in water. The use of this clay as a coagulant reduced the carbonate hardness of the Iowa River water from 250 p.p.m. to about 200 p.p.m. About 300 lbs. of bentonite per million gallons reduced the total hardness of the river water to about 100 p.p.m. Professor Olin states that the use of sodium bentonite as a coagulant is relatively independent of the pH value of the water

treated. Lime softening of a water which contains carbonate hardness presents a particularly favorable situation for the use of bentonite in clarification.

#### EXPERIENCE AT ATLANTA

Increased rate of consumption at Atlanta, together with a pronounced oily pollution in the Chattahoochee River water, materially added to the burden of the purification plant in producing a satisfactory finished water. Two conditions were most evident: (1) Insufficient time for mixing and settling resulted in light floc formation. (2) Taste and odor complaints were caused by increased rate of plant operation and complexity of treatment.

Many experiments were made in an endeavor to attain greater plant efficiency by rearrangements and combinations of existing material and equipment. Activated carbon was effective in materially reducing unpleasant taste and odor but it did not aid appreciably in the formation of a tougher and more rapidly settling floc.

Innumerable jar tests were conducted on the river water using both fuller's earth and bentonite. The most successful of these tests were subjected to plant scale trials. Fuller's earth was used for this purpose because of its availability and favorable cost (See specifications at end of this paper).

Three different points of application were studied on plant scale tests to determine the most effective combination. One had alum added about five minutes before clay; another had alum and clay added simultaneously; and the third had clay added about five minutes before alum (9). The application of alum and clay at a common point proved most conducive to a quick settling floc. This procedure has been used at Atlanta for more than four years when raw water turbidities are less than 100 p.p.m. The amount of clay used in these early tests varied from 2 to 250 lb. per million gallons with an average of about 20 lb. p.m.g. The amount of alum used averaged 65 lb. p.m.g. During this time the quantity of carbon applied in the last section of the sedimentation basin was reduced from 15 lb. to 8 lb. p.m.g. Daily threshold odor tests control the application of clay and carbon. We endeavor to maintain a pO threshold value of about 2 in the finished water at all times. This combination of materials has resulted in a more highly refined water and also a definite reduction of complaints. This has helped to establish a more friendly relationship between the public and the water department.

Observations at Atlanta indicated that clay has little or no action on the chlorine that is applied to the raw water. On the contrary, chlorine appears to be held in the surface of the coagulated masses. Thus the deposited sludge in the sedimentation basin is kept in a fresh condition. In 1930 (See fig. 1) at the bottom of one of our sedimentation basins the bacterial count was 10 million. In 1933 chlorine sterilization of the raw water reduced this count to 2 million, and in 1938 the application of clay reduced the count to 600,000. We believe that this improved condition was brought about by the presence of chlorine laden clay in the lower strata of the basin. It is a practice at Atlanta to measure the depth of sludge in the sedimentation basins each month. A typical cross section of these measurements will be found in table 1.

TABLE 1  
*Sedimentation basin operation at various depths in inlet pass*  
Atlanta Water Works—Dept. of Purification

DEPTH WATER	pH	CO <sub>2</sub>	ALKALINITY	TURBIDITY	CHLORINE RESIDUAL	DEPTH MUD
<i>feet</i>		<i>p.p.m.</i>	<i>p.p.m.</i>	<i>p.p.m.</i>	<i>p.p.m.</i>	<i>feet</i>
2	6.6	4.0	10.7	45	0.35	0
4	6.6	3.8	10.7	60	0.20	0
6	6.6	4.0	10.0	90	0.15	0
8	6.6	4.2	10.4	125	0.10	0
10	6.6	4.5	10.0	2,000	0.05	1
12	6.5	10.0	19.0	150,000	0.0	3
14	6.3	45.0	56.0	350,000	0.0	5

Note: Approximately 750,000,000.0 gallons of water, treated with coagulant and clay, passed through this basin during the four month period of this test.

About a year ago an auxiliary mixing chamber was built in order that an additional volume of coagulated water might be obtained to supplement that from the regular process. This basin is used intermittently. It has a capacity for 4 to 15 million gallons daily. The supply is derived from a second stored-river-water reservoir in which there is a minimum of circulation, permitting a luxuriant growth of microorganisms. The turbidity of this water seldom exceeds 50 p.p.m. It is colored and susceptible to very unpleasant odors. It has a pH value of 6.8, CO<sub>2</sub> of 2.5 p.p.m., and hardness of 15 p.p.m. The average period of detention in this chamber is only 15 minutes or one-third that of the regular unit. This necessitates larger amounts of coagulant.

Last fall, alum was used in this mixing chamber without clay. The filter runs were reduced from 120 hours to 71 hours and the cost of wash water increased appreciably. However, when 40 lb. per million gallons of clay was added, with alum coagulation, the filter runs were restored to normal and the cost of wash water reduced 30 per cent (See table 2).

TABLE 2

*Water treatment with and without clay*

Atlanta Water Works—Department of Purification

	REGULAR OPERATION RES. NO. 2 WATER	AUXILIARY OPERATION	
		Res. No. 1 water without clay	Res. No. 1 water with clay
Turbidity.....	150.0 p.p.m.	45.0 p.p.m.	45.0 p.p.m.
Alum application (pounds per m. g.)..	60.0 lb.	210.0 lb.	217.0 lb.
Clay application (pounds per m. g.)...			40.0 lb.
Time mixed.....	45 min.	15 min.	15 min.
Time settled.....	8 hr.	8 hr.	8 hr.
Settled water turbidity.....	10.0 p.p.m.	17.0 p.p.m.	11.0 p.p.m.
Filter runs (between washing).....	120 hr.	71 hr.	120 hr.
Filter loss of head.....	4.8 ft.	8.5 ft.	7.2 ft.
Filtered water pH.....	6.8	6.4	6.4
Tap water pH (lime added).....	8.5	8.5	8.5
Tap water turbidity.....	0.3 p.p.m.	1.2 p.p.m.	0.7 p.p.m.
Tap water pO (odor).....	2-E	4-M	3-M
Filter washings (per month).....	6.0 times	10.3 times	6.0 times
Wash water per filter (million gallons per month).....	1.02	1.751	1.020
Wash water cost @ \$25.00 per m. g. (7 filters).....	\$178.50	\$306.43	\$178.50
Wash water saved by use of clay per month.....			127.93
Cost of clay per month.....			\$ 36.00

Note: Approximately 35 m. g. of water is used daily from No. 2 Reservoir. Water from No. 1 Reservoir is used intermittently with rate varying from 4 to 15 m. g. daily.

#### CONCLUSION

The regular use of about 20 lb. of clay at a cost of ten cents per million gallons, with alum application, has increased the efficiency of water treatment at Atlanta from 10 to 30 per cent.

Fuller's earth or adsorbent clays materially improve alum coagulation on many waters having a turbidity of about 100 p.p.m. or less.

A heavy floc is formed which settles rapidly, producing good coagulation, and the water filters out crystal clear.

Clay is inert towards the chlorine it adsorbs. When deposited in the sludge area of many sedimentation basins it has a tendency to reduce putrescence, odors, and even coliform bacteria. (See fig. 2)

When clay forms a tougher and more adsorbent floc with alum, in colored waters, there is a tendency to remove the color almost proportional to the amount of clay used.

Frequently, when clay is used with the coagulant, objectionable materials are removed from the water before they interfere with

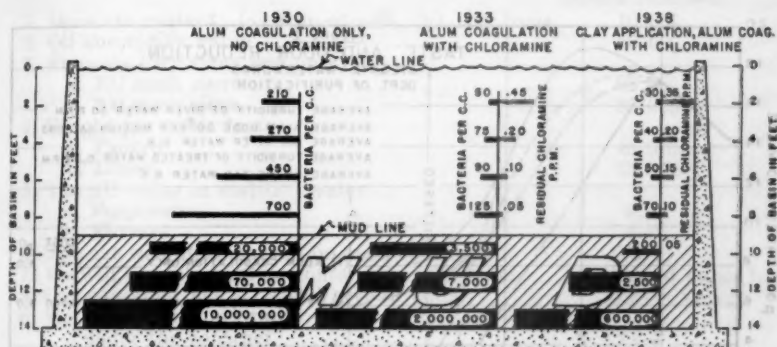


FIGURE 1  
BACTERIA AND RESIDUAL CHLORAMINE CONCENTRATION  
AT VARIOUS DEPTHS IN SEDIMENTATION BASIN  
(INLET PASS)

ATLANTA WATERWORKS  
DEPT. OF PURIFICATION

subsequent treatment in the purification process. This insures more effective and economical use of adsorbing and sterilizing materials.

Bentonite clays have proven effective as a coagulant in a number of water softening plants, especially when the water contains magnesium sulphate.

Clay with zeolitic properties has been known to reduce the total hardness of a relatively hard water when used instead of other coagulants.

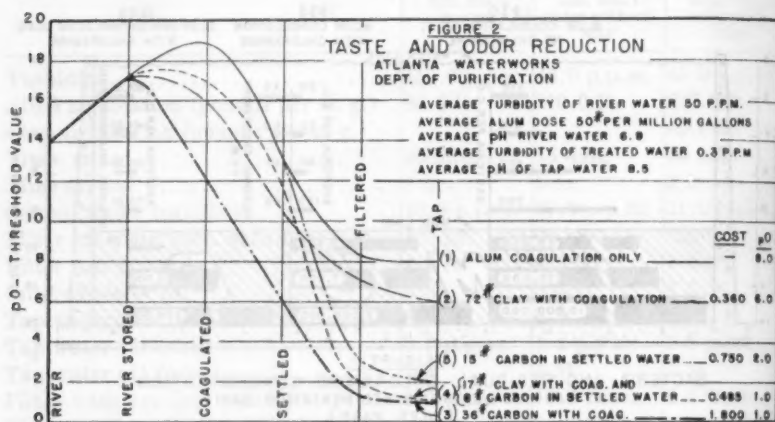
Most water conditioning clays are inexpensive and can be purchased for about one-half to one and one-half cents per pound.

Our experience at Atlanta indicates that, when clay is applied in the raw water, and carbon in the settled water to the filters, they become complementary. Thus, their combined effectiveness to

improve coagulation and reduce taste and odor surpasses that of either when used separately (See fig. 2).

It is not the purpose of this paper to advocate fuller's earth (adsorbent clay) or bentonite clay as a panacea for all coagulating and taste and odor evils but, rather, to bring out facts and procedures which may be of benefit to the individual.

I wish to express my appreciation to W. Z. Smith, General Manager of the Atlanta Water Department, for his suggestions and help in conducting the clay tests at Atlanta, to the Water Purification Plant Employees, and to all who have generously contributed data for this discussion.



#### REFERENCES

1. SLOCUM, DR. EDWARD M. Action of Absorbent Clays in Water Systems. Jour. Penna. W. W. Oper. Assn., vol. 4 (1932).
2. DODD, RENNIE I. The Use of Absorbing Clay for Removing Taste and Odor Producing Substances from Water. Jour. Penna. W. W. Oper. Assn., vol. 4 (1932).
3. NORCOM, GEORGE D. Bleaching Clay in Water Purification. W. W. and Sew., 80: 53 (1933).
4. ALEXANDER, CARL. Drippings from the Georgia Faucet, 2: 3 (1938).
5. BAYLIS, JOHN R. Bleaching Clays, W. W. and Sew., 80: 287 (1933).
6. GRAY, ODELL W. Discussion of a paper by DR. EDWARD M. SLOCUM, "The Removal and Sterilization of Organic Detritus by the Use of Adsorbent Clay." Jour. Southeastern Sec. A. W. W. A., 7: 57 (1937).
7. OLIN, H. L., AND PETERSON, H. W. The Use of Bentonite as a Coagulant in Water Treatment. Jour. A. W. W. A., 29: 513 (1937).
8. OLIN, H. L., AND GAULER, J. V. The Use of Bentonite Clays in Water Treatment. Jour. A. W. W. A., 30: 498 (1938).

9. MITCHELL, LANE, Assoc. Prof. Ceramics, Georgia Tech., Atlanta, Ga. A similar series of coagulation tests were made with bentonite clay. Private correspondence, October 31, 1934.

### SPECIFICATIONS ON WATER CONDITIONING CLAY FOR 1937

#### ATLANTA WATER WORKS, ATLANTA, GA.

The following questions shall be answered and submitted with each bid on Clay. No bid will be considered unless these questions are completely answered.

The Water conditioning Clay that we propose to furnish the City of Atlanta, Georgia during the year 1937 for water purification purposes will meet the following specifications:

	(Material Purchased)
1. Moisture content: (a) Run-of-mill; (b) Dry basis.....	10.0%
2. Oil absorptive value.....	60.0%
3. Fineness (dry sieve test only):	
a. 100 mesh sieve.....	98.0%
b. 200 mesh sieve.....	85.0%
4. Weight per cubic foot:	
a. Packed.....	40.0 lb.
b. Loose.....	25.0 lb.
5. The pH value in distilled water:	
a. Suspension.....	6.2
b. Filtrate.....	6.8
6. The net weight is marked on each container.....	Yes
7. We will furnish dustless containers. Describe.....	Sewed paper bag
8. Our container has a Bates Valve or equal.....	Bates Valve
9. We guarantee uniformity in all shipments delivered under the contract.....	Yes
10. Delivery will be made in — days after receipt of order.....	5 days
11. Submitted herewith is a one pound sample of clay representative of our proposed average run-of-mill.....	
12. Trade name of Clay offered.....	Pikes Peak
13. Location of manufacturing plant.....	Macon, Ga.
14. Name of firm bidding.....	General Reduction Company

The City of Atlanta reserves the right to accept or reject any or all bids and to award the contract to the best interest of the City, all technicalities waived.

The requirements of the City of Atlanta for the year 1937 are a minimum of 40 tons and a maximum of 100 tons, for delivery during the year of 1937.

Deliveries to be made f.o.b. Atlanta Water Works, Hemphill Pumping Station, Southern Railway, Atlanta, Georgia, in such quantities and at such times as the City of Atlanta, through its proper officials, may direct.

Note: A copy of the above specifications was sent to each firm submitting a bid on Atlanta's Clay requirements for 1937. The contract was awarded to the firm submitting the highest quality product in the opinion of the City. (Material purchased indicated by right hand column.)

*Discussion by RENNIE I. DODD.\** Mr. Weir's experience with clay has been of special interest to me because in 1930 we began using clay at the Chester, Pa. plant. So far as we know this was the first plant in the United States to use this treatment.

While we have heard from time to time of small plants and industries using clay, Mr. Weir's is the first case comparable to ours which has come to our attention. It is quite consoling, for seven years is a long time to be alone even with a method of water treatment.

It is particularly interesting to learn that, with the exception of the point of application, Mr. Weir's experiences with adsorbent clay have been quite similar to ours. An instance is his experience with auxiliary mixing chamber treatment, first without clay and then with clay, showing an increased efficiency of from 10 to 30 per cent by the addition of clay. We also have discontinued the use of clay while trying other materials or during periods when the raw water supply was especially good. We have always, upon returning to the clay treatment, found a marked improvement in the quality of the finished water as well as in the purification costs.

These improvements are no doubt due, as pointed out by Mr. Weir, to the formation of a stronger and more adsorbent floc, the adsorptive power of the clay particles themselves, more rapid settling, and the resultant decrease in the filter load.

The behavior of clay, however, will depend upon the condition of the water being treated. The raw water at Chester contains a variety of industrial wastes. In some cases it has been found, while comparing the effectiveness of clay and carbon for odor removal, that small doses of clay and small doses of carbon reduced the odor intensity to about the same degree, but that when larger doses were used carbon was much more effective. At other times, however, large doses of clay compared more favorably with carbon than did small doses. This seems to confirm Mr. Weir's idea about the advisability of using a preliminary clay treatment followed later on in the process by carbon.

Mr. Weir's bacteriological examinations of the sludge from the sedimentation basins throws further light on action of the chlorine laden clay on the sludge. While we have not examined the sludge bacteriologically, we have noticed that the use of clay reduces odor in the sludge. We have found that chlorinated dry clay will retain the chlorine over a long period of time, and that chlorinated clay

\* Chemist in Charge, Chester Water Service Co., Chester, Pa.

when added to water will form a fine (small) floc. Upon the addition of a small amount of alum an excellent floc is formed.

Mr. Weir mentions the mystified layman who is told about the use of clay to remove turbidities. He might have gone further and said that many of the non-technical water plant operators were equally mystified and skeptical. To try to explain with such expressions as coagulation of colloidal suspensions, complex physical phenomenon, etc., only tends to further complicate the matter.

I find that to the non-technical a comparison of the coagulation process to rain or snow storms and the comparison of the removal of impurities to the clarifying of the atmosphere after the storm give them a conception of colloidal precipitation with which they are familiar. Then, manipulation of the coagulation materials in the plant becomes to them a mere mechanical control.

On the whole I have agreed with Mr. Weir's paper. However, on one or two points I am inclined to differ, if only in opinion. His statement about the swelling of certain clays and the process by which this swelling is brought about strikes me as being at least open to discussion. There has always been a question in my mind about how these so-called adsorptive materials really work.

It is difficult to conceive of these minute particles, many millions to the cubic inch, having so much capillary space available. In the case of the swelling variety, if one particle when wet swells to eleven times the original size, would a bag, say of one cubic foot of dry clay, swell to eleven cubic feet if wet? I am inclined to think the whole matter is merely a case of surface wetting and the swelling probably only apparent.

More research such as Olin and Gauler are doing will add much to the knowledge of the more technical operator.

## THE MERIT SYSTEM OF DALLAS, TEXAS APPLIED TO WATER WORKS EMPLOYEES

BY J. B. WINDER

The Dallas city government is the Council-Manager type. The controlling body consists of nine councilmen, one of whom is elected mayor by the council. He is usually the councilman receiving the largest number of votes. The council is elected for a term of two years, and the terms are not overlapping.

The council appoints the city manager, who in turn appoints the heads of the various departments, such as chief of police, fire chief, director of public works, director of the health department, superintendent of water works, etc. The city manager and the department heads are not under civil service.

The Civil Service Board is composed of three citizens appointed by the mayor and approved by the council. This board serves for the two-year term.

Before anyone can secure a position in the water department (except common labor) it is necessary that he submit an application for the position in which he is interested, stating his qualifications, experience, education, etc., giving references as to previous employment, general character, etc. All positions are classified according to the nature of the work. Each classification contains certain specific requirements as to education and experience.

An Eligible Register for each classification is created by holding an examination of the applicants for the particular classification. These examinations are generally written, with some exceptions where a combination of written and oral examination is given, such as for a senior engineer or public relations man. After the examinations, the references are fully and carefully checked. The applicants making grades of 70 per cent or better are declared eligible and set up on the register according to the grade made, the one making the highest grade heading the list, and so on down. Reference letters

---

A paper presented at the New Orleans convention, April 25, 1938, by J. B. Winder, Supt., Dallas City Water Works, Dallas, Texas.

are sent out to past employers and references; also, the education and age are verified by writing the school indicated.

Each classification has a salary range from minimum to maximum, usually a \$50 range, paid according to length of service and general proficiency.

Whenever the department is in need of additional help, the department head determines the classification under which the proposed employee belongs; and also determines if funds are available for this service. If funds are found available, the department head makes a request to the personnel department for such an employee. The personnel department checks for funds available and to see if the budget appropriation provides for such a position. If the request meets the approval of the personnel department, the request is submitted to the secretary of the Civil Service Board, who certifies to the department head three names from the top of the list for that certain classification from which the proposed employee is chosen. If for any reason a person whose name has been certified does not answer the call, or is no longer interested in the prospective position, then the department head may request the secretary of the Civil Service Board for additional names to be submitted to him for consideration. If the department head is not satisfied to employ any of the ones certified to him, then he may submit his reason for not being willing to accept the same; and if the secretary of the Civil Service Board approves of the reasons stated, additional names will be certified. The reason for submitting three names for one vacancy is to give the department head an opportunity to use his judgment as to which one might be best qualified from the standpoint of his personality and traits.

After the department head selects the employee, he submits the selection to the personnel department for final approval, and they in turn notify the secretary of the Civil Service Board.

Before he may begin work, it is necessary for this prospective employee to pass a health examination to determine if he is physically fit. Thereafter he must pass an examination during each 12-month period.

Every new employee is put on a ninety-day probation period. During this time his performance is carefully watched, and at the end of each thirty days a rating sheet is made covering his performance, and the same submitted to the Civil Service Board. At the end of this ninety-day period, if the performance of the employee

is satisfactory, his employment is made permanent. If the performance is not satisfactory, the employee is dismissed—he may be dismissed before the expiration of the ninety days if his actions or performance are not satisfactory. If the employee is dismissed from the service within the ninety-day period, he has no recourse to the Trial Board. In case of dismissal this employee may or may not be re-instated on the eligible register, depending upon the reasons for his dismissal.

Whenever a position to be filled is of such classification as to be a promotion to certain employees (such as, general clerk to senior clerk; etc.), then the employees take a “promotional examination.” This is conducted in much the same manner as the original examination, except that the applicants must be employees of the city, in the next lower classification, and have at least six months service on a permanent basis. If none of the promotional eligibles are satisfactory, then the employee is selected from the eligibles that have not had previous employment with the city. Employees may be eligible under more than one classification, if they so elect.

The Civil Service Board requires the department head to fill out an efficiency rating form every ninety days. On this rating form the department head appraises the performance of the employee, and from this appraisal, the Civil Service Board sets up what is known as an “Efficiency Rating.” Employees’ ratings begin with 75 per cent as a base and stop at 100 per cent which is the maximum. If the person graded is an average employee, the rating will not change; if he is above the average, or for standard satisfactory service, he may earn  $\frac{1}{4}$  of 1 per cent additional each ninety day period. For outstanding performance, the employee may secure additional credits up to  $1\frac{1}{4}$  per cent; or if the performance is of such a nature as to warrant special recognition, the Civil Service Board may grant credits in keeping with the value of the special work performed. For instance, the Civil Service Board granted L. C. Billings, chemist in charge of purification, an additional credit of 7 per cent for working out and perfecting the use and application of chemicals for coagulation at the purification plant, which effected a saving of about \$4,000 per year.

Employees passing the examination for licensed operators earn an extra  $\frac{1}{4}$  per cent. Completing outside study or work that increases the usefulness of the employee, devising new and useful methods of doing work, performing heroic acts, etc., entitle employees

to additional credits. It is necessary, however, that efficiency credits and debits be substantiated by facts properly supported.

Employees who are doing unsatisfactory work will receive a penalty under these ratings. This penalty may range from  $\frac{1}{4}$  per cent up to 2 per cent at any one quarterly marking, according to the gravity of the negligence or carelessness in his work. Also, the Civil Service Board has the right to review the markings made by the department and, if they believe they are justified, change the marking up or down. Thus it is possible for the Civil Service Board to declare at any quarterly rating that the employee has fallen below the required grade of 70 per cent and order a hearing. If the grade of an employee falls below 70 per cent, he is called before the board and dismissed from the service, unless he can show satisfactory cause. Usually the department head has already taken some action before the matter reaches this stage.

Should an employee commit any overt act which may be deemed a sufficient reason for the department head to recommend his dismissal, the department head may make such recommendation to the city manager, setting forth the reasons why such employee should be dismissed, and supporting the same with proper information. If the city manager concurs, he may order the dismissal of the employee. The personnel regulations of the city provide that the dismissed employee may appeal to the city manager within five days for a hearing before him. If the result of this hearing is not satisfactory to the employee, he may, within ten days from the date of his dismissal, demand a public hearing before the Trial Board. This request is filed with the secretary of the Civil Service Board.

The Trial Board consists of two members of the city council and one member of the Civil Service Board, usually the chairman of the board. The personnel of the Trial Board does not change except as administrations change.

The secretary notifies the Trial Board, and they set the date for the public hearing. This dismissed employee may employ an attorney to represent him, and he may secure witnesses for his defense. The Trial Board may reinstate the employee, or they may order the employee suspended for a certain period, or they may order his dismissal, in which case the employee has no further recourse except to the courts, and that usually avails him little.

The water department had one case where it ordered the dismissal of an employee in the meter division, the reason being that

## CIVIL SERVICE BOARD

## SERVICE RATING FORM "A"

(Presenting evidence of unusual acts or accomplishments of one employee only)

INSTRUCTIONS: First check any act or result listed on this sheet which the employee has performed during this period. If the employee did not perform any one of the acts or results here listed, use Form "B".

Second, after checking any item listed on this sheet, turn the sheet over and specify full objective details thereof—the particular facts of this case—on the reverse side. The details must evidence the conclusion in order to substantiate the rating proposed. One item only should be checked to detail any one performance.

Period: \_\_\_\_\_ to \_\_\_\_\_, 19\_\_\_\_

Employee's name: \_\_\_\_\_ Department: \_\_\_\_\_

Position: \_\_\_\_\_ Salary: \_\_\_\_\_

(Group 1. Any one or more items checked in this group will, when substantiated by objective specifications, entitle employee to increase or decrease of  $\frac{1}{4}$  per cent in any period.)

Check:

- | Item:  | Specify Details Over |
|--|----------------------|
| <input type="checkbox"/> Item: 1 On own initiative devised new and useful system or device.                        |                      |
| <input type="checkbox"/> " 2 Performed act injurious to public welfare or property or service.                     | " " "                |
| <input type="checkbox"/> " 3 Performed heroic act.   | " " "                |
| <input type="checkbox"/> " 4 Neglected duty resulting in detriment to public welfare or property or service.       | " " "                |
| <input type="checkbox"/> " 5 Voluntarily performed unique service of extraordinary value.                          | " " "                |
| <input type="checkbox"/> " 6 Acted dishonestly, was intoxicated on duty, or was insubordinate.                     | " " "                |
| <input type="checkbox"/> " 7 Established unique record for quantity or quality of work.                            | " " "                |
| <input type="checkbox"/> " 8 Absence without leave resulted in detriment to public welfare or property or service. | " " "                |

(Group 2. Any one or more items checked in this group will, when substantiated by objective specifications, entitle employees to increase or decrease of  $\frac{1}{2}$  per cent in any period.)

- | Item:  | Specify Details Over |
|--|----------------------|
| <input type="checkbox"/> Item: 1 Completed outside study or work which increased usefulness.                       |                      |
| <input type="checkbox"/> " 2 Acted carelessly or with misjudgment, resulting in detriment to service.              | " " "                |
| <input type="checkbox"/> " 3 Performed work of unusual responsibility effectively in addition to own routine.      | " " "                |
| <input type="checkbox"/> " 4 Accomplished insufficient work results.   | " " "                |
| <input type="checkbox"/> " 5 Performed much overtime work (own or that of others) without additional compensation. | " " "                |
| <input type="checkbox"/> " 6 Frequent lateness or absence impaired usefulness.                                     | " " "                |
| <input type="checkbox"/> " 7 Performed own work under unusually difficult conditions with unusual distinction.     | " " "                |
| <input type="checkbox"/> " 8 Temperament, disobedience, or violation of rules resulted in detriment to service.    | " " "                |

SPECIFY DETAILS OF ALL ITEMS CHECKED . . USE REVERSE SIDE

## CIVIL SERVICE BOARD

## SERVICE RATING FORM "B"

For Employees Not Reported on Form "A"

(Describe work characteristics of twenty or less employees holding the same position.) Instructions: List the names of all employees covered by this report here:

Names	Position	Names	Position
1. _____	_____	2. _____	_____
3. _____	_____	4. _____	_____
5. _____	_____	6. _____	_____
7. _____	_____	8. _____	_____
9. _____	_____	10. _____	_____
11. _____	_____	12. _____	_____
13. _____	_____	14. _____	_____
15. _____	_____	16. _____	_____
17. _____	_____	18. _____	_____
19. _____	_____	20. _____	_____

Observe the number before the name of each employee listed above. The column hereunder, headed by the number of each such employee, refers to the work traits possessed by him. For each employee place a check in his column after each work trait, if and only if it fairly describes his work, or him. This card will not be used for comparative rating. These employees are eligible to receive the standard satisfactory increment of one-half per cent per rating period unless one or more unfavorable characteristics are checked each period. Check all applicable items.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Dependable - - - - -																				
Sometimes violates rules - - - - -																				
Tactful - - - - -																				
Often late - - - - -																				
Learns quickly - - - - -																				
Co-operative - - - - -																				
Slow in work - - - - -																				
Careless - - - - -																				
Conscientious - - - - -																				
Accurate - - - - -																				
Poor appearance - - - - -																				
Has initiative - - - - -																				
Indifferent - - - - -																				
Trouble maker - - - - -																				
Resourceful - - - - -																				
Gets much work done - - - - -																				
Uses poor judgment - - - - -																				
Inspires others - - - - -																				
Has valuable experience - - - - -																				
Unprogressive - - - - -																				

Department \_\_\_\_\_

Signature of Reporting Officer. \_\_\_\_\_

he had cursed and threatened bodily injury to a waitress who had asked him to pay for food and beer that he purchased at the cafe where she worked. This employee demanded a public trial and summoned witnesses in his defense. The Trial Board sustained the city manager and approved the dismissal of the employee.

Another way in which employees may be removed is by three citizens filing, with the Civil Service Board, a written charge or charges of misconduct against any officer or employee. The Civil Service Board makes an investigation and, if the charges are confirmed, then the Board files the charges with the Trial Board. If demanded by three citizens, the accused employee is then tried.

The efficiency ratings of the employees have a bearing on which employees will be kept in the service, in case a reduction in forces becomes necessary. Efficiency ratings also affect promotions and salary.

All pay rolls are carefully checked by the Civil Service Board to ascertain that the names on the pay rolls are for the proper salary and classification.

The city manager may authorize increases in salary within the salary ranges established for the particular classification and within the appropriation of the budget, without requesting approval of the city council.

Employees are granted two weeks vacation annually. They are also allowed twelve days each year for sick leave, provided they have had a personal physical examination within the twelve-month period. Should an employee have failed to obtain such physical examination, then he will be required to make up the lost time by working extra, if the department should have extra work to be done which otherwise would necessitate the employment of extra help. In extreme cases the sick leave may be extended, upon recommendation of the department head and approval of the director of public health and the personnel department. Employees may also apply their vacation time against the sick leave.

Water department employees have been under civil service for six years, and so far it has worked out satisfactorily to employees as well as to the department.

So far, Dallas has had an honest and conscientious Civil Service Board and secretary. It is entirely possible for a council to appoint a Civil Service Board that will do the political bidding of the members of the council, in which case civil service might not fare so well.

## WATER SOFTENING AT MINNEAPOLIS

By J. A. JENSEN

The purpose of this paper is to describe the softening and filtration of a water supply for Minneapolis obtained from the upper drainage basin of the Mississippi River, and to explain the action of the double cone type precipitator for the clarification of the treated water which is to be used in connection with the existing filtration plant.

### WATER CHARACTERISTICS

The Mississippi River drainage basin above Minneapolis comprises an area of about 19,000 square miles. The surface area of the basin is composed of glacial drift and terminal moraines formed by recession of successive ice sheets leaving a rolling terrain of wooded areas and prairie land and the inclusion of a large number of Minnesota's 10,000 lakes. The southwesterly portion of the drainage basin is largely tilled soil while the northeasterly section consists of cut-over land and second growth woods and considerable individual areas of marsh land.

The drainage consists of surface run-off, overflow from lakes and marshes, and seepage from the drift along the river channel and from its tributaries. From these sources are contributed the general characteristics of the water. In winter the stream flow is at a minimum with ground water predominating. The water then has its maximum hardness and greatest freedom from organic matter and color. In spring and summer the run-off from melting snow and rains produces a softer water which added to the normal stream flow of ground water dilutes its mineral constituents, and the resulting volume is a water of minimum hardness and, at intervals, of maximum color.

The color is of organic origin and is derived from the individual marshy areas. It appears as a peaty stain and its existence prevails during a period required for its reduction by oxidation. Many

---

A paper presented at the New Orleans convention, April 26, 1938, by J. A. Jensen, Engineer, Water Works Dept., Minneapolis, Minn.

coffee colored streams whose flows are retarded sufficiently in intervening lakes lose their color by oxidation in such reservoirs. Certain algae grow in profusion throughout the summer season.

The urban population along the river above is scattered in smaller towns with rather incomplete sewerage systems. The largest city, St. Cloud, has a population of 21,000, but is situated 75 miles above Minneapolis. These are the principal sources of undesirable contamination, but the distances are such that no serious filter loadings arise. Under state control these communities will eventually be required to provide adequate sewage disposal for the protection of downstream water supplies.

#### EXISTING WATER TREATMENT

Since 1913 the water supply has been clarified with aluminum sulphate, passed through rapid sand filters, and sterilized with chlorine. At times when conditions required, use has been made of chloramines and/or activated carbon to alleviate objections not eliminated by filtration alone.

At present there are two filtration plants. The first plant at Columbia Heights, completed in 1913, is located three miles distant from the river and at an elevation from which the filtered water is delivered to the easterly portion of the distribution system by gravity. Its capacity is 78 million gallons daily. The second plant, at Fridley, is located near the river and the filtered water is delivered into the westerly portion of the system by direct pumping and equalizes with the gravity supply in the southern part of the city beyond certain partial separations of the pipe system. The capacity of this plant is 80 m.g.d. The total filter capacity of the two systems is 158 m.g.d.

#### PROPOSED WATER SOFTENING

The proposal to soften the water supply has been under consideration for a number of years, but necessity for expansion of plants and distribution system has caused its temporary postponement. During the present lull in general growth and activity the need for expansion has ceased for a time, and opportunity to further this improvement has become possible.

There are few natural surface waters that possess all of the essential qualifications of a wholesome and pure water. For this reason purification and other processes are used in order to condition water

to meet such requirements. Water must be free from disease bacteria, objectionable taste or odor, turbidity, color, excessive hardness, and other undesirable constituents. Popular demand for such water is more insistent and the activity to meet this situation is increasing. More capital is being invested in these operations for the enterprise is not without its compensating features. A dollar and cents appraisal of water having these qualifications either by nature or after proper conditioning will run into surprising figures, and expenditures for softening usually prove to be self liquidating and therefore financially justifiable.

The softening problem at Minneapolis consists normally of moderating the calcium and magnesium carbonate content of the water supply. The hardness in terms of calcium carbonate for the past six years may be taken as typical for a sub-normal rainfall period. For normal rainfall or over, the trend would be somewhat lower. The monthly averages and periodic fluctuations show a range from 150 p.p.m. to 206 p.p.m. Extremes for shorter periods have been noted from 99 p.p.m. (1922) to 232 p.p.m. (1925). The average hardness for the six year period, 1930-35, was 172 p.p.m. In the treatment it is proposed to reduce this to 75 p.p.m.

In the early summer months a high color may appear, which in a water of this hardness will require auxiliary treatment for its reduction. A record kept for the past 23 years gives the minimum, maximum, and mean for each year. The average color range is from an average minimum for the 23 years of 14 p.p.m. to an average maximum for the 23 years of 101 p.p.m., with a mean of these averages of 35 p.p.m. It is proposed to maintain a color of not more than 10 p.p.m. in the finished water. By experimental work it has been quite definitely determined that the normal lime treatment will reduce the color to this standard if the original color does not exceed 75 p.p.m. The record further shows that, on an average for the 23 years, the color exceeded 100 p.p.m. 7 days per year and that it was in excess of 75 p.p.m. for an average of 24 days or 6.6 per cent of the time. This indicates that color removal by auxiliary methods will be required approximately 24 days each year. The worst year of record for color in excess of 75 p.p.m. was 1937 with 72 days over that figure. 1933 was worst for color over 100 p.p.m. when there were 29 days, of which 22 were over 125 p.p.m.

The normal mode of operation, therefore, will be to modify the hardness of the water by lime and auxiliary coagulation, and after

stabilization the effluent will be divided when it leaves the carbonation chamber for delivery to the adjacent Fridley filters by low service pumping and by high service pumping to the Columbia Heights filters, three miles distant. At these plants the water will idle through the existing coagulation basins to the filters as at present and after sterilization be delivered to the city. When a color in excess of 75 p.p.m. appears, all of the raw water will bypass the softening plant and flow directly to the Fridley mixing chambers and coagulation basins. Aluminum sulphate will be applied to reduce the color to the requisite 75 p.p.m. which brings it within the limited control of the lime softening treatment. After this partial color reduction the water will flow back to the softening plant for normal treatment, following which it will be divided between the two plants as before described, except that the softened water during this short period will be delivered directly to the Fridley filters since the coagulation basins there will be in use for color removal.

#### EXPERIMENTAL STUDIES

Extensive experimental work has been in progress for nearly four years on this water. Models of conventional rectangular basins, cylindrical clarifiers, and cone type precipitators have been studied using varying forms of mixing or agitation, and several combinations of treatment and clarification.

These studies with this water appear to have demonstrated the following results:

1. Rapid settlement of sludge by sedimentation separates the water from the lime before full reaction takes place. This is shown by returned sludge furthering the reaction and increasing the degree of softening.
2. Deposited sludge subjects the included organic matter to deterioration. If returned it may impart tastes and odors to the treated water.
3. In conventional tanks at least three to four hours retention is necessary.
4. Retained suspended sludge in a regulated degree of concentration is highly effective in its action upon the calcium and magnesium constituents of this water.
5. A high degree of stabilization and clarification is obtained in one and one-half hours or less of retention and contact time in retained suspended sludge.

The water softening process consists primarily of modification of the amount of mineral salts which contribute to hardness. The first attack is the reduction of the calcium and magnesium carbonates to a predetermined degree. Incidentally it must be observed that the reactions do not follow perfectly to give the desired results without attendant difficulties. The presence of other salts, variable pH concentration, temperature, and other factors tend to influence the stability of the treated water. In arriving at a saturated solution there must be an intimate contact during the solution and solid phases of the reaction. Agitation and the practical time element alone do not provide this required saturation without other aids. Filtration through lime coated filter sand readily brings about added stabilization. Due to the after-deposits upon filter sand this would not be practical. Similar results are also obtainable by passing the water through detained concentrated lime precipitates. Such detained sludge, to produce contact to the fullest degree, must be in suspension so that a uniformly continuous flow may slowly mingle and pass through it.

These prerequisites and their favorable solution led to the adoption of the Spaulding precipitator for use in the Minneapolis plant. The funnel form tank would produce the conditions and action as outlined. Hydraulically the vertical flow upward through such a container has a decreasing velocity in the expanding cross-sectional area. The rising water carries the floc to a level that is self selective according to the carrying power of any velocity and the size or weight of the particles. Thus the floc finds equilibrium in a distinct horizontal plane. Kept within the proper range, this makes it possible to retain the continually forming sludge at any desired concentration and regulate it by drawing off any surplus when necessary.

These principles of the funnel are modified but slightly in a practical and economical design of the operating precipitator applied to practical use. It is supplied with mechanical agitation to assist in keeping the particles in suspension and to prevent unbalancing pressures and flows. In effect the funnel has been cut in a horizontal plane near midpoint. The smaller cone is inverted and placed inside the larger. The water is applied at the top, flows to the bottom of the inner cone, and then turns and rises in the outer cone through an annular opening left between the two sections. A cylindrical chamber is added for the turn and here the agitator is placed for maintaining suspension, mixing, and equalization of the detained



sludge. The inner cone is supported clear above the chamber by radial baffles resting on the outer cone. These baffles assist in equalizing the vertical flows and prevent swirling or rotating currents.

The standard rise of water in the precipitator is adopted at two inches per minute at a level just below the weir or overflow plane. Rate of clarification is affected by temperature and other conditions of the water, but by this type of precipitator the time of retention has been reduced to ninety minutes or less.

This precipitator makes use of continually forming fresh sludge within a brief period of time. The regulated concentration and periodic drawing off required obviate the possibility of deterioration of organic matter or algae in the sludge.

The sludge concentration in the precipitator will be held at about two per cent in the agitation chamber. It will be intermittently pumped to a concentrator tank or thickener. Auxiliary treatment with a small amount of alum or iron sulphate and sodium silicate to assist in precipitation and soda ash for tempering sulphates may be used as aids when deemed advisable.

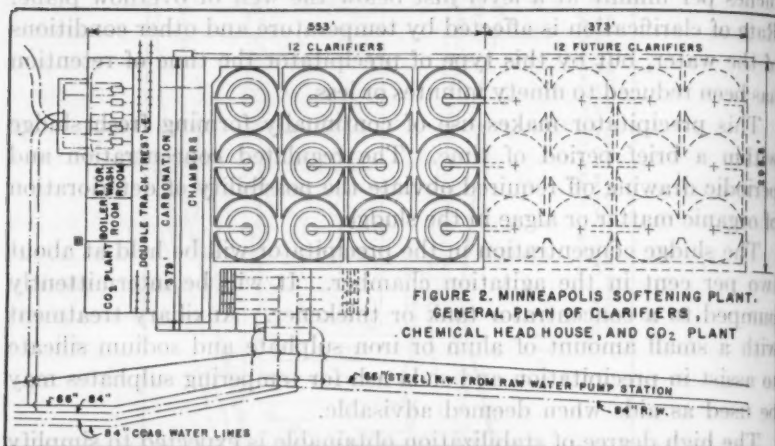
The high degree of stabilization obtainable is expected to simplify or moderate the application of recarbonation after softening. The use of produced carbon dioxide and dry ice have both been considered as suitable for the purpose. The choice will be determined by the relative cost of these methods.

#### THE SOFTENING PLANT

The softening plant is located at the river between the pumping station and the filters at the Fridley site. It will consist of twelve precipitators, a low service pumping station, chemical house, a system of influent and effluent conduits, carbonation chambers, sludge concentrators, and disposal beds and all the necessary mechanical equipment. The basins will be enclosed in a building to prevent freezing at the surface of the water.

The precipitators will each have a nominal capacity of 10 m.g.d., or a combined capacity of 120 m.g.d. They are of re-inforced concrete construction and occupy an area 296 ft. by 379 ft. Due to their form and design they present a novel problem in form work and construction. Because of a foundation in gravel and sand, the outer basins are all supported on a slab footing of varying thickness and reinforcement. The outer cone is supported on sixteen radial buttress walls and the cone is equipped with four expansion

joints at the quarter points. The shell of the cone is supported on horizontal girders, run straight between buttresses. The increasing length of each girder from the lower edge of the cone to the weir at the top presented some intricate form work. In pouring the concrete



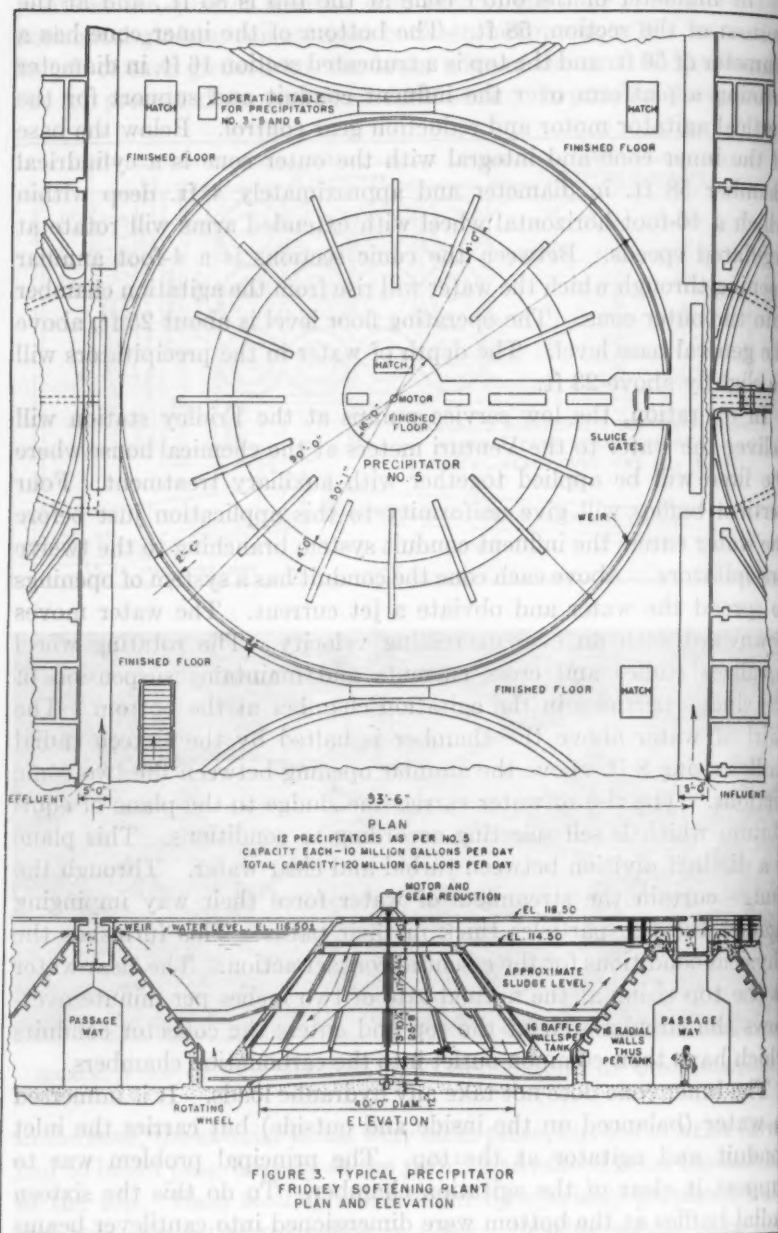
AERIAL VIEW OF PRECIPITATORS IN VARIOUS STAGES OF CONSTRUCTION

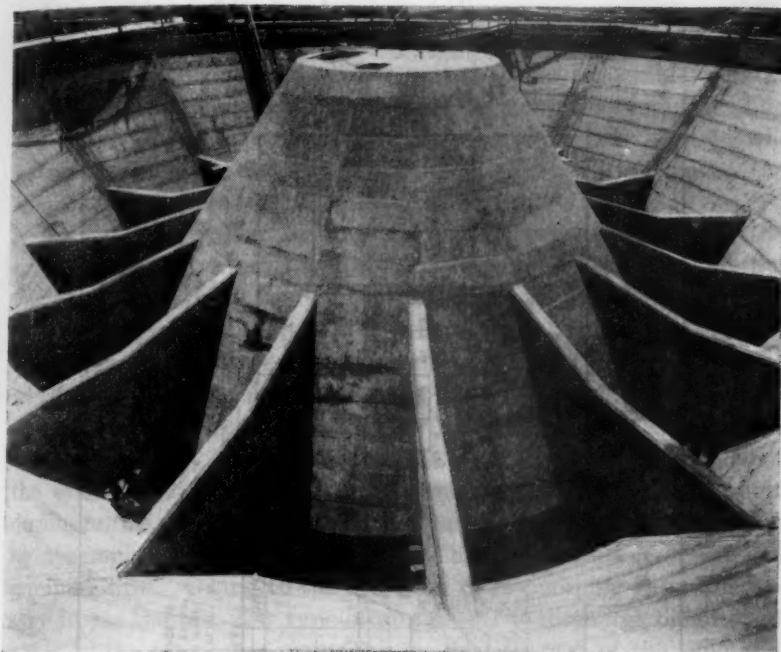
in the cone, the exterior forms were all in place, but the interior forms had to be set progressively as the pouring advanced from the bottom to the top. Each section was secured by specially prepared bolts and nuts, the latter remaining in place. Spacing spools were held also by the same bolts and left in place.

The diameter of the outer cone at the top is 85 ft., and at the bottom of the section, 58 ft. The bottom of the inner cone has a diameter of 50 ft. and the top is a truncated section 16 ft. in diameter forming a platform over the influent conduit and support for the vertical agitator motor and reduction gear control. Below the base of the inner cone and integral with the outer cone is a cylindrical chamber 58 ft. in diameter and approximately 4 ft. deep within which a 40-foot horizontal wheel with extended arms will rotate at regulated speeds. Between the conic sections is a 4-foot annular opening through which the water will rise from the agitation chamber into the outer cone. The operating floor level is about 25 ft. above the general base level. The depth of water in the precipitators will be slightly above 23 ft.

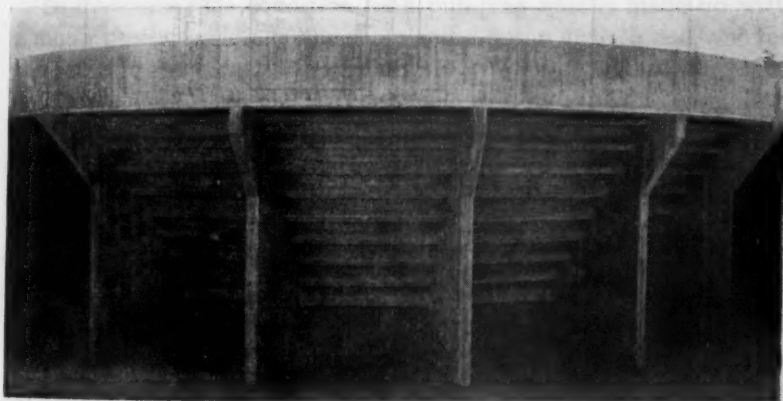
In operation, the low service pumps at the Fridley station will deliver the water to the Venturi meters at the chemical house where the lime will be applied together with auxiliary treatment. Four vertical baffles will give uniformity to this application just before the water enters the influent conduit system branching to the twelve precipitators. Above each cone the conduit has a system of openings to spread the water and obviate a jet current. The water moves downward with an ever decreasing velocity. The rotating wheel equalizes eddies and cross currents and maintains suspension of the sludge particles in the agitation chamber at the bottom. The swirl of water above the chamber is halted by the sixteen radial baffles rising 8 ft. above the annular opening between the two conic sections. The rise of water carries the sludge to the plane of equilibrium which is self selecting according to conditions. This plane is a distinct division between turbid and clear water. Through the sludge curtain the streamlets of water force their way impinging against the floc particles thick in their paths. This furnishes the physical conditions for the essential contact action. The clear water at the top rising at the normal rate of two inches per minute overflows the circular weir at the top and enters the collector conduits which have their common outlet into the carbonation chambers.

The inner cone does not take any hydraulic loads. It is immersed in water (balanced on the inside and outside) but carries the inlet conduit and agitator at the top. The principal problem was to support it clear of the agitation chamber. To do this the sixteen radial baffles at the bottom were dimensioned into cantilever beams and the inner cone is thus supported coincidently on the radial buttresses of the outer cone. The stresses in the inner cone are borne





INTERIOR OF PRECIPITATOR UNIT



EXTERIOR OF PRECIPITATOR UNIT

by two ring beams, the one at the lower part of the cantilever and the one at the upper part being in reverse stresses. These are joined by a beam system to support the shell.



At one side of this chamber is a shallow sump with two outlets, one connecting to the sludge pump and the other to a larger pump to drain the precipitator when required. The adjustable weir at the top of the outer cone forms the inside of a circular conduit leading the water away. The outer space between the precipitators will be quite ample for access and passages. Here will be placed the sludge pumps, drain lines, electric conduits, and other auxiliaries.

The collector system leading the clarified water away from the precipitators unites into a long conduit which enters two carbonation chambers, each 30 ft. by 320 ft. These are arranged with gates to operate in parallel and alternately when cleaning is required. Grids will be placed near the entrance for the application of carbon dioxide when required. At the exit end the water will be divided for delivery to the two widely separated filtration plants.

Due to limiting space between the river level and flow level of the existing Fridley filters, the alternative handling of the water during normal operation and during periods of high color could not be accomplished without re-pumping and modification of present pumping lifts. Owing to the low head of re-pumping it was necessary to use the mix-flow type of pumps. The discharge of softened water to the raw water mains for coagulation part of the time and the direct delivery to the filters part of the time would create a "cross-connection" between raw water conduits and the filters.

To overcome this condition each pumping unit is made up with a motor on the middle of the shaft and a pump at each end, one for the raw water connection and the other for the Fridley filter plant delivery. The operation is to be regulated by selective couplings. The initial installation will include three such double pumping sets with 25, 40, and 50 m.g.d. capacity pumps.

The chemical house is 63 ft. by 215 ft. and will cover the intake control chamber and meters, control valves, and laboratory. The upper floors will contain the storage bins for lime and auxiliary supplies of iron sulphate, alum, and soda ash. A double track will enter the buildings and cars will be under cover. The lime and other materials will be unloaded by vacuum conveyors and distributed from the pent house hoppers by screw conveyors. The chemicals for treatment will be drawn from the hoppers at the bottom of the bin above the grade floor. Lime will be poidometer-belt dry fed to continuous slakers. These will be of the heat exchanging type. After application the water will be distributed by way of the

influent conduit system to the precipitators for reconditioning and clarification.

The twelve precipitator agitators will be driven by direct current motors through a gear reduction of 150 to 1. The peripheral speed of the agitator wheel has a range between 0.75 and 10.5 ft. per second. Specially built motor generator sets and potentiometer type rheostat control with compensation for varying distance line losses will produce fine speed regulation. By this means the speed of all agitators can be controlled simultaneously from one station.

The drawn-off sludge will be pumped to a thickener or sludge concentrator with a flow line sufficiently high above the precipitator level so that the supernatant water at the concentrator will be returned to the influent conduit by gravity. The concentrated sludge will be pumped to prepared sand filters or lagoons with subsurface drainage for drying to a consistency that will permit it to be loaded out for agricultural use, reclaiming, or filling purposes.

The two low service pumping stations at separate points will be coördinated by a central control arrangement. The main gates of the conduit lines will all be electrically operated and will be included in this system so that the operator will be able to control the volume and direction of the water by a visible signal system covering the pumps and gates.

The portion of softened water to be filtered at the Columbia Heights plant will be delivered by gravity to the Northeast pumping station for high service delivery. The 66-inch conduit will be connected to the existing pump suction pipes and the present river intake will be closed. By reason of the flow line build-up at the softening plant the existing suction lift at this station will be practically eliminated at full station capacity. At other times there will be a small positive head at the suction side of the pumps.

The portion of water to be filtered at the Fridley plant will pass from the carbonation chamber to the suction well of the Fridley re-pumping station for delivery to that plant. The filtered softened water from both plants will be distributed by the methods now employed, i.e., by gravity from Columbia Heights and by high service pumping from Fridley.

#### ADVANTAGES OF SOFTENED WATER

As a conditioning process that has a parallel in other industries, the softening of a municipal water supply acquires a number of important advantages, both qualitative and economic.

The primary prerequisites of a water supply are its quality and suitability for the health and use of the community. Water softening and filtration are elimination processes. None of the reagents employed remains in the water. Alum and lime precipitate and, in sedimentation and filtration, literally sweep out turbidities, algae, and combined minerals, not desirable in the water. These agglomerates further perform other actions that are as yet not fully explained. As a result there is produced from a natural surface product a sparkling water that will compare satisfactorily with the best supplies that have yet been developed—a water moderate in minerals and free from taste, odors, disease producing bacteria, and other impurities.

Soap and washing compounds serve to soften the water in the home. There is little cleansing power until soap has neutralized the calcium and magnesium salts. With a softened water the amount of soap and compounds will be greatly reduced and this saving will be returned to the consumer. The annual saving in soap alone averages three times as much as the annual costs of softening the water with lime.

The original investment for municipal softening is one-tenth that of individual softening. The operating cost of the community softener is one-twentieth that of a home softener.

In softening with lime treatment the lime serves as a purifying as well as a softening agent. Lime is a most effective and economical germicide.

Taking sufficient hardness out of water to make it satisfactory for all domestic and commercial purposes in a public supply has demonstrated that it is desirable not to remove the total hardness much below about 75 parts per million. Further reduction would merely add materially to the operating costs, with no appreciable advantage.

A large saving comes in decreased fuel bills by reason of less fuel required for heating where a non-scale water is used in power and heating plants. Investigations show this saving to run from 5 to 10 per cent of the annual fuel bills.

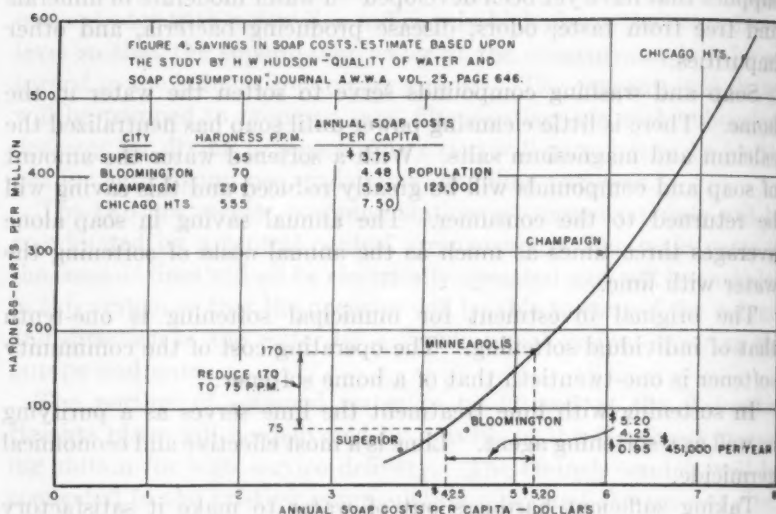
To a housewife the soft water brings longer life to fabrics and linens by reason of milder suds. Fine washable apparel, table linens, shirts and collars can make more trips to the wash tub if a gentler water is used and at the same time pay dividends by longer use.

A great deal of comfort will come from the use of soft water in the laboratory and bath. Persons with tender skin will find it a

pleasure because of decreased application of toilet soap and bath preparations.

The softening of water for municipalities has been accomplished along with filtration and at a slight additional cost. Plants are now designed to provide for softening and softened water is considered a strong civic asset.

No investment by the city gives greater returns to its citizens and of all municipal improvements, none has proven so universally popular as plenty of soft water. Cities with soft water are in a



position to assure new industries of reduced annual operating production costs by reason of suitable soft water.

Some of the results of a study of the volume of soap used in proportion to the hardness of the water supply are of interest at this time.

According to the survey of soap consumption made by H. W. Hudson, University of Illinois, (see fig. 4), in the cities of Superior, Bloomington, Champaign, and Chicago Heights, it was demonstrated that the per capita soap costs varied in proportion to the hardness of the water used in those cities. By plotting a curve showing the relationship between hardness and soap costs it is possible to apply the curve to other waters. By placing Minneapolis water at 170 p.p.m. on the curve its soap cost appears at \$5.20 per capita per year. By reducing this hardness to 75 p.p.m. the soap cost

becomes \$4.25 per capita per year or a reduction of 95 cents per person. At the present population the softening of the water to this degree indicates a saving to the consumer of \$451,000 per year for soap alone.

The estimates made of treatment per million gallons based upon the preliminary experimental work on water softening followed by filtration are as follows: treatment in softening plant \$8.47; filtration after softening \$8.68; labor in softening plant \$2.18; additional pumping \$0.60; auxiliary light and power \$0.14; and heating \$0.45. The total is \$20.52 per million gallons. The present actual cost of filtration alone is \$13.51. By a combination of the two processes the amount added on account of softening is the difference between these units or \$7.01 per m.g. The annual added cost of operation for the softening of 20,000 m.g. will amount to \$140,200, which is about one-third of the above saving of \$451,000 in soap alone.

The cost of the plant is estimated at \$2,500,000. Construction expenditures to date are about \$750,000, paid out of departmental surplus.

The design and proportioning of the Spaulding precipitator has been based upon the essential requirements for the Mississippi River water at Minneapolis. The principles of its performance have been governed by extensive experimental work directed by Charles H. Spaulding, originator of this device.

The engineering features of this plant have been laid out around these precipitators and coördinated with the general methods of operation of the existing purification plants. All the plans and details have been worked out and all construction is carried on by force account under the supervision of the officials and engineering group of the Minneapolis Water Department.

*Discussion by* CHARLES H. SPAULDING.\* Of the rather numerous water softening plants which are under construction at the present time, the Minneapolis plant is no doubt the largest and most important. Mr. Jensen is to be congratulated that his department is bringing this improvement in the quality of the water supplied to the people of his city. The quality as it relates to hardness is of importance as much as some other qualities and means much more in economy than the cost of the improvement—as this paper has indicated. We give considerable attention nowadays to turbidities

\* Supt. of Water Purification, Water, Light, and Power Dept., Springfield, Ill.

in tenths of a part per million. There is the possibility that we are sometimes too concerned with the appearance and neglect the substance.

Mr. Jensen has presented the results obtained during a twelve-month period at the experimental softening plant. Since the data submitted do not show the proportions of calcium and magnesium in the Minneapolis water it is perhaps well to mention that this supply is one in which the magnesium exceeds considerably the equivalent non-carbonate hardness. Hence, the softened water contains appreciable amounts of magnesium carbonate. This magnesium carbonate could be removed by excess lime treatment followed by recarbonation but it is allowed to remain because a satisfactory softening to about 70 p.p.m. can be obtained with lime treatment to normal carbonates and with but little recarbonation. Roughly half of the alkalinity or temporary hardness remaining in this case is magnesium carbonate. The average alkalinity for the period shown is 53.5 p.p.m. which in view of the magnesium and the long duration of low temperatures is a better result than could be obtained in a much longer period of treatment with a conventional type of plant.

This point of difference in Minneapolis raw water from some others is but one of a number which may be expected in any particular case. It is one of the functions of experimental treatment in advance of such a project that it uncovers such idiosyncrasies as exist and thereby prevents over-design in one feature at the expense of another.

It is fortunate in the case of precipitator operation that small models are giving almost identical results with large scale performance when the essential features are identical. The first plant scale unit ever constructed had 900 times the area of the laboratory model which preceded it and yet results in either could be duplicated in the other. This should not be so surprising in view of the vast amount of useful filter information which has been obtained in recent years with small glass filters.

The most important variables in precipitator operation are—time of agitation in contact with accumulated sludge; the speed of rotation of the agitator; the upward velocity of the treated water at the point where it leaves the sludge; and, the concentration of the sludge. When these features are the same in two units, it matters not what their relative sizes may be in the experience which is accumulating at a rather rapid rate.

It should be apparent that with such a laboratory tool a large

amount of valuable information can be obtained in a very short time concerning the behavior of a given water under treatment. Such treatment in the model is continuous and resembles plant scale operation very closely.

At Minneapolis with the four-gallon unit (4 gal. per min.) in more or less continuous operation, information as to coagulation, color removal, and recarbonation requirements is being accumulated in advance of completion of the full scale plant. This pilot plant operation will clear the way of many problems which would otherwise accumulate during the tuning up period of the new plant.

*Discussion by MALCOLM PIRNIE.\** The continuing improvement in methods of water purification is brought forcefully to the attention of waterworks men by Mr. Jensen's excellent description of the experimental work and design resulting from it which have been executed under his direction at Minneapolis. His conclusions as to the fundamental principles involved in upward flow reaction and precipitation confirm those reached by the writer in studies, designs, and operations carried out during the past three years at widely separated points and following the principle of upward flow contact iron removal plants in successful operation in Florida for the past twelve years.

Successful washing operations for mechanical filters containing layers of sand or lighter layers of crushed anthracite depend upon equal distribution of wash water to the supporting gravel, and upon uniformity of the successive horizontal layers of graded gravel sufficient in depth to still all eddies and currents caused by the introduction of the wash water. Successful washing operations depend to an even greater extent upon a blanket of uniform filtering material of uniform depth and of sufficient depth above the gravel. When such a layer of filtering material is suspended in the upward current of wash water, its expanded surface will be level and each square foot of area will pass identical quantities of wash water. A layer of anthracite will be expanded and the grains suspended in the upward flowing water by a much lower rate of flow than is required for a bed of sand containing grains of equal size. Similarly a bed of precipitated calcium carbonate will be suspended by a somewhat lower rate of upward flow of water than a bed of ferric hydroxide floc.

The extension of the filter washing principle to the design of precipitators is simply a modification of area related to rate of upward

\* Cons. Eng., 25 W. 43rd St., New York, N. Y.

flow which will suspend the precipitate in a given depth without raising its expanded surface to the level of the outlet weirs or orifices. Precipitators of this type for calcium carbonate and ferric hydroxide floc have been in successful operation at the split treatment softening plant of the Pinellas Water Company serving St. Petersburg, Florida since 1936. Precipitators for ferric hydroxide floc have been used at Pocantico Hills, New York and at the new paper mill of the West Virginia Pulp and Paper Company at North Charleston, South Carolina for about one year. Experimental plants for aluminum hydroxide floc at Newport, Rhode Island and for ferric and man-ganic hydroxide flocs at Piedmont, West Virginia confirm the results obtained in the purification plants in regular operation.

As the result of experience to date it is indicated that lime treatment reaction and precipitation basins should be designed for a maximum upward flow rate of 0.1 ft. per min. or 1.2 in. per min. and ferric hydroxide reaction and precipitation basins should be designed for a maximum upward flow rate of 0.125 ft. per min. or 1.5 in. per min. At these rates water which is practically clear can be drawn from the tops of basins 15 ft. in depth if the accumulating sludge is partly withdrawn periodically to prevent accumulation of volume sufficient to be expanded to the level of the outlets.

Figure 1 is presented to indicate the relative sizes of circular basins (which may be of wood, steel, or concrete, each provided with a center well) that are required for various rated capacities. A 50-foot diameter tank for lime treatment without coagulant is rated 2 m.g.d. and for coagulation 2.5 m.g.d. A 100-foot diameter tank for lime is rated 8.3 m.g.d. and for coagulation 10.2 m.g.d.

In circular basin design, the water is introduced to the center well preferably tangentially and dosed at entrance with lime or in the supply pipe with a coagulant. At the bottom of the well radial pipes project to the walls of the tank, each perforated with equal diameter holes so spaced that equal ring areas are served by equal numbers of orifices. Orifice size is selected to give 0.2 foot loss at entrance of the mixed water to the bottom of the tank, and size of lateral pipes is selected to limit loss in them to less than 10 per cent of a 10- to 15-foot loss through the orifices. Desludging is effected by opening a gate in a drain connected through the bottom of the center well of size sufficient to discharge the volume of water delivered by the laterals with the center well drawn down from 10 to 15 ft. Head on the orifices for desludging is therefore from 50 to 75 times the head on them for distribution of the mixed water through

them. Each lateral with its straight line of orifices is rotated 45° upward from the tank bottom in the same direction. Lateral connections to the center well can be made in one or more horizontal planes.

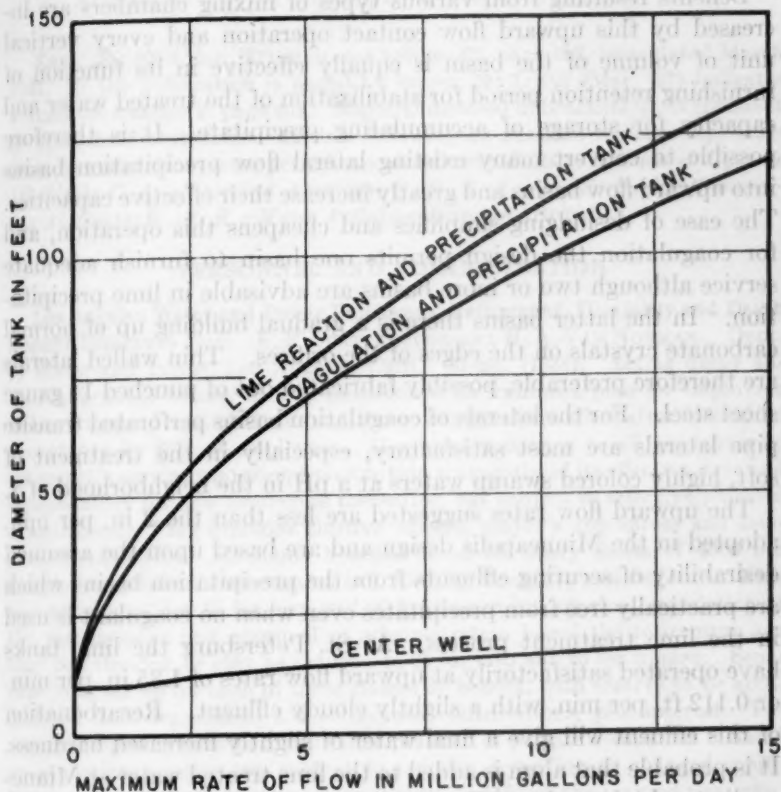


FIGURE 1. UPWARD FLOW REACTION AND PRECIPITATION TANKS FOR LIME SOFTENING AND COAGULATION.

UPWARD FLOW RATES

LIME - 0.10 FT. PER MIN. = 1.2 IN. PER MIN.

COAGULATION - 0.125 " " " = 1.5 " " "

The dosed and mixed water enters the bottom of the tank in hundreds of jets at a velocity of 3.6 feet per second, mixing thoroughly with the heavier bottom layer of precipitate and blanketed by a 6- to 10-foot bed of expanded precipitate. The water rises upward uniformly at a rate of 0.1 to 0.125 ft. per min. This provides more than an hour contact period for surface adsorption to play its im-

portant part in completing the reaction. Water containing dissolved oxygen is in contact with all of the precipitate which prevents putrefaction of organic matter and the oldest portion of the sludge is withdrawn at each desludging operation.

Benefits resulting from various types of mixing chambers are increased by this upward flow contact operation and every vertical unit of volume of the basin is equally effective in its function of furnishing retention period for stabilization of the treated water and capacity for storage of accumulating precipitate. It is therefore possible to convert many existing lateral flow precipitation basins into upward flow basins and greatly increase their effective capacities. The ease of desludging simplifies and cheapens this operation, and for coagulation the design permits one basin to furnish adequate service although two or more basins are advisable in lime precipitation. In the latter basins there is a gradual building up of normal carbonate crystals on the edges of the orifices. Thin walled laterals are therefore preferable, possibly fabricated out of punched 14 gauge sheet steel. For the laterals of coagulation basins perforated transite pipe laterals are most satisfactory, especially in the treatment of soft, highly colored swamp waters at a pH in the neighborhood of 4.

The upward flow rates suggested are less than the 2 in. per min. adopted in the Minneapolis design and are based upon the assumed desirability of securing effluents from the precipitation basins which are practically free from precipitates even when no coagulant is used in the lime treatment process. At St. Petersburg the lime tanks have operated satisfactorily at upward flow rates of 1.35 in. per min. or 0.112 ft. per min. with a slightly cloudy effluent. Recarbonation of this effluent will give a final water of slightly increased hardness. It is probable that alum is added to the lime treated water at Minneapolis to obtain a clear effluent when the basins are operating at a rate of 2 in. per min.

This discussion is in the nature of a progress report on operations similar to those which have been reported at Minneapolis. There is no doubt that this method pays dividends by the saving in chemicals. Knowledge of the effect of temperature and pH upon rated capacity is needed for proper rating in various circumstances. Substantial differences are suggested by knowledge of variations in wash rates with temperature for equal expansion of sand beds. Factors other than temperature which cause changes in the viscosity of the liquid in the upward flow precipitation process should be investigated for specific treatments as has been so thoroughly done under Mr. Jensen's direction.

## ABSTRACTS OF WATER WORKS LITERATURE

**Key.** 29: 408 (Mar. '37) indicates volume 29, page 408, issue dated March 1937. If the publication is pagged by issues, 29: 3: 408 (Mar. '37) indicates volume 29, number 3, page 408. Material inclosed in brackets, [], is comment or opinion of abstractor. Initials following an abstract indicate reproduction, by permission, from periodicals as follows: *B. H.*—*Bulletin of Hygiene (British)*; *C. A.*—*Chemical Abstracts*; *P. H. E. A.*—*Public Health Engineering Abstracts*; *W. P. R.*—*Water Pollution Research (British)*.

### PERSONNEL AND ADMINISTRATION

**Los Angeles Water and Power Employees' Retirement, Disability and Death Benefit Insurance Plan.** E. F. SCATTERGOOD AND H. A. VAN NORMAN. Dept. of Water and Power, Los Angeles, Calif. 50 pp. (1938). Acting under authority granted by city charter amendment an insurance plan for employees of Los Angeles Dept. of Water and Power has gone into effect after individual acceptance by 80% of employees. Membership is open to all employees of six month's service who accept plan within six months of its effective date and is mandatory for new employees thereafter, but subject to selective physical examination. Plan excludes elective officers, mayor's appointees and temporary employees. Maximum benefits based on salary limits of \$500 per month for retirement allowances and \$300 for disability and benefits. Normal retirement age 65 for men and 60 for women but on recommendation of the management and approval of administration board the retirement age may be extended, or may be reduced to 60 for men and 55 for women. Separate fund set up for each of three classes of benefit, with reserve to be accumulated from department and employees' contributions, plus interest. Reserves computed as in best insurance practice of private companies. Based on preliminary estimates, subject to revision according to changed conditions, entire cost of insurance plan will be 15.44% of the insured pay rolls: 6.85% from employees and 6.61% from department for retirement, disability and death benefits; besides which the department will pay 1.98% of the insured pay roll for sick leave allowances to employees electing to subscribe. *Retirement allowance* includes (1) annuity in amount earned on retirement date by employee contributions, plus actual interest on same up to 3%, plus capital gains or losses and distributed surplus (2) pension for current service equal to earnings on retirement date on department contributions, plus items just stated. Sum of (1) and (2) calculated to yield 1.5% of beginning salary times years of current service. Salary raises will increase sum of (1) and (2) but not produce at normal retirement 1.5% of time-weighted av. In addition to current service retirement there will be a prior-service allowance equal to 1.25% of av. monthly compensation for year before adoption of

plan times years of prior service. Minimum earned retirement allowance \$40 a month, or \$31.50 for females electing to contribute at stated reduced rates. Contribution rates for current service retirement are 49% by employee and 51% by department. Total prior service allowance paid entirely by department amortized for 30 yrs. *Temporary disability allowance*, av. flat rate, all ages, both sexes; 60% paid to fund by employees, 40% by department. Rates adjusted to actual experience, increased ultimately to actual operating expense and contribution to service according to formula adopted by administration board. *Permanent total disability rates* based on av. age of group and amount of benefit in force on effective date of plan; otherwise as for temporary disability. Exempt from contributions to this fund while absent from disability or while receiving workman's compensation. Disability payments only for actual period, not to exceed 6 mos. for temporary disability; for complete disability, not beyond normal retirement age. Payments for 6 mo. to 3 yr. service, 100% of pay first 2 weeks of disability, 85% next 2 wk., then 40%; 3 to 5 yr. 100% for first 2 wk., 85% next 4 wk., then 40%; 5 to 10 yr., 100% for 2 wk., 85% for next 6 wk., then 40%; over 10 yr., 100% first 2 wk., 85% next 16 wk., then 40%. *Death Benefit* contributions based on estimated amt. of insurance at estimated av. attained age of group on effective date of plan, apportioned 60% to employee, 40% to department, readjusted at end first fiscal yr. to actual amount of insurance at av. attained age of group, and thereafter ultimately to experience rating formula adopted by board of commissioners of department. Employee payments waived during disability. Benefits range from \$1,000 to \$3,000, actual amounts 10 times classified monthly salaries, plus return of total accumulated contributions to retirement fund. Board of Administration composed of one member of Los Angeles Board of Water and Power Commissioners, Chief Engineer and General Manager of Bureau of Water Works and Supply, same officer of Bureau of Power and Light, chief accounting employee or controller of department and three contributing members elected by active contributing members. Board subject to control and direction of the Water and Power Commissioners. Investment of funds in hands of administration board subject to state laws on investment of savings banks or public funds.—M. N. Baker.

**Water Engineers' Responsibilities.** ANON. Surveyor (Br.) 93: 717 (May 27, '38). *Report of inaugural address by J. F. HASELDINE*, President, Inst. of Water Engineers. Many wild and expensive schemes have been suggested involving construction of works required only in rare periods of drought; whereas as an alternative in such periods consumption might be curtailed as much as 20% by suitable advertising of the situation. Problem of fixing a standard of quality for water is not as simple as for food or drugs; hence the statutory "pure and wholesome" must be obtained through proper technical control. Sampling for analysis should be more frequent where sterilization is not continuous. Hence, the safest policy is to adopt sterilization as a matter of discipline and to advertise the fact as is done in America. Precautions should be taken against contamination of works during construction, and, by periodic inspections, against contamination of watersheds. Power of the water works authority to adopt ordinances is so restricted by the Minis-

try of Health as to preclude adoption of present British Standard Specification. Unfortunately the responsibility for maintaining fire hydrants is legally on the water works but the cost is to be paid by the town. It is the obligation of the water-works authority to provide and maintain service pipes at its own expense. Practice has tended towards the provision of the first service pipe at the expense of the consumer, but the cost of maintenance is borne by the water-works authority. The right of the water company to lay a pipe in a private street is restricted to the size necessary for the immediate district. Water works are the most important utility to be protected against air raids. Information obtained by a water survey of the kind published in the Surface Water Year Book should be extended because of the urgency of its need.—H. E. Babbitt.

**Bacteriological and Chemical Control of Water Supplies.** ANON. Surveyor (Br.) 93: 713 (May 27, '38), 93: 757 (Jun. 3, '38), 93: 805 (Jun. 10, '38). *Report of paper by A. E. PALMER AND H. N. H. LANDER before Inst. of Water Engineers.* The paper is an excellent sequel to the presidential address by J. F. Haseldine (see preceding abstract). The costs of the many water examinations and analyses at the Barnet water works is found to be only 0.096 pence per 1,000 gal. (Imp.), which is practically negligible to the consumer. Quality of water controlled by technical supervision of the sterilizing devices and by frequent chemical and bacteriological analysis of samples collected at various points in district. *Discussion.* JOHN BOWMAN: 30 m.g.d. (Imp.) are delivered unchlorinated to Edinburgh with not one case of water-borne disease in 120 yrs. H. D. CHEESEWORTH: Has been practice of the Sheffield Water Dept. to chlorinate all supplies and to maintain small residual throughout the area. Daily tests for free chlorine and pH are made at key points of the entire system. J. T. CALVERT: The value of bacterial analysis is emphasized through maintenance of a high standard of quality. Cost of each bacteriological analysis seems to run about 10 shillings. G. W. HALL: The work of the chemist of South Staffordshire Water Co. includes: 1. Knowledge of all raw waters to be treated. 2. Supervision of all treatment processes. 3. Maintenance of pure and wholesome water leaving all pumping stations. 4. Preservation of this quality throughout the district. 5. Examination of water resources of the district in light of future development. Water can undergo pronounced changes in quality during its passage through distribution system. Speaker gives statistics in support of this statement. Frequency of sampling is necessary with respect to both time and place. A. E. RAWSON: At North Mimms Pumping Sta. alum treatment has varied between 10 and 100 p.p.m., a high figure for such waters, particularly ones derived from chalk. Occasional use of sodium aluminate has reduced cost of treatment, assisted the filters, and often produced better filtrate. Application of 0.3 p.p.m. chlorine to the water of New Barnet, which is of good quality, and its almost immediate discharge into distribution, is contrary to the speaker's idea of good practice which requires an appreciable period of retention. Doubt expressed as to efficacy of a dose of 0.3 p.p.m. in the event the water became really polluted. Dechlorination of water containing so small a concentration of chlorine seemed useless to the speaker but since the authors

considered it desirable the neglect of chloramination was surprising. Probably treatment with potassium permanganate was all that was necessary to guard against post-chlorination tastes. The public is interested in the quality of water as it reaches the consumer, not as it leaves the pumping station. Hence samples should be taken in the district rather than at pumping station. A. B. E. BLACKBURN: Air-raid precautions, typhoid threats, and statements in the president's address point out more needed precautions than all water engineers can adopt. Danger of going to too great an extreme. Not necessary that all precautions be applied by every water authority. T. V. JOHNS: Use of chlorine residuals of 0.1 to 0.2 p.p.m. has eliminated peaty tastes at Lowestoft. Likewise red water difficulties have been eliminated by chloramination. D. HAMILTON THOMPSON: Experience at Portsmouth showed pollution of previously sterile water by excreta from sea gulls. Difficulty overcome by stretching net work of wires with a 10' x 20' mesh over the filters. Gulls then stayed away. B. W. BRYAN: The requirement by Ministry of Health that a qualified engineer be employed in a water works undertaking is impracticable for populations under about 4,000. A. E. PALMER (closing): Nominal period of contact for chlorine at most of the pumping stations was 30 to 45 min. This would be too short for chloramination. At certain times iodoform tastes were reported and probably hydrogen peroxide treatment would be tried to eliminate it.—*H. E. Babbitt.*

**Water Supply Questions.** ANON. Surveyor (Br.) 93: 858 (Jun. 24, '38). *From inaugural address of H. M. MEDLAND, President, British Waterworks Assn.* Trend towards amalgamation of small public service units into large organizations has not yet touched the water works industry as a whole, although certain governmental committees have been considering the matter for some yrs. Importance of pure water and its relation to public health has been emphasized by the Croydon outbreak. Publicity and propaganda are great aids in reducing costs. Recently announced decision of Government to legalize payment of 50% of cost of approved schemes of air-raid protection indicates success of this organization's Executive Committee in presenting the problem to Government. Protection of watersheds causing constantly increasing difficulties to impounders of moorland waters. Our industry is proud of its record in caring for comfort and safety of our people.—*H. E. Babbitt.*

**Purity of Water Supplies. Engineers' Duties and Responsibilities.** R. G. HETHERINGTON. Surveyor (Br.) 93: 813 (Jun. 17, '38). (with editorial comment on p. 809). Records important in water works on valve locations, pressure zones in distr. system, and pipe location around pumping station. Such records are particularly essential due to air-raid threats as the water engineer may be killed in the raid. Sources of supply must constantly be protected and there is no excuse for statement that pollution within 2 mi. of an intake was unknown. Only analyses can indicate contamination of an underground source. Routine precautions include physical examination of operating employees; supervision of sanitation within and about the plant; chlorination of equipment in contact with the water, before returning it to service; provision of adequate toilet facilities on construction work, and strict supervision

of their use. Service reservoirs and filters must be guarded from contamination, and made inaccessible to unauthorized humans and animals. Periodic cleaning, including chlorination, of the service reservoir. There should be continuous record of chlorine applied and modern type liquid-chlorine apparatus. Proper and regular analysis is the engineer's chief guide as to what is happening, and whether his precautions are sufficient. Analyst should be given the opportunity for occasional inspection of the surroundings from which samples are collected.—*H. E. Babbitt.*

**Water Supply and Town Planning.** G. H. THISELTON-DYER. Off. Cir. Br. W.W. Assn. 20: 17 (Jan. '38). Instances are given of manner in which English law governing town planning may be of service to water authorities.—*Martin E. Flentje.*

**Insurance of Waterworks Property.** ANON. W.W. Inf. Exch., Canadian Sect., A.W.W.A. 2:C:2:10 (Nov. '37). Following data are given regarding insurance of Canadian waterworks: parts of system insured, who insurance is carried by, annual premiums paid, total value of waterworks, amount of insurance carried, percentage of total waterworks value covered by insurance and av. annual fire loss for 10-yr. period. Of 87 municipalities for which data are given, 70 carry insurance. In 65 of these insurance is carried by a company and by the municipality in 3 instances; no data are given for the other 2. Amount of insurance carried varies from 0.13 to 31% of the value of the waterworks property, being <5% in 30 instances, 5% or more but <10% in 16, 10% or more but <15% in 7 and >15% in 4; no data given for 13 of the municipalities. Annual premiums paid by the 70 communities total \$10,147.32. Losses by fire were experienced in only 9 of the municipalities in 10-yr. period, av. annual loss being \$3,928.60 (\$1,667.60 of latter amount is accounted for by fire in New Westminster, B.C., in '31).—*R. E. Thompson.*

**How to Avoid Legal Pitfalls.** LEO T. PARKER. W. W. Eng. 91: 20 (Jan. 5, '38). Proper exercise of police power by water companies is defined as well as effects of the due process clause of the Federal Constitution. A contract for the use of land for water purpose is legal even if it is dedicated for this purpose without a cash consideration. It is well established that a jurisdiction of the Public Service Comm. cannot be conferred by implication. It must be given by State laws. The power of fixing rates does not apply to the fixing of a rate when there is in existence a contract entered into between a munic. corp. and a water works company. Another important rule of the law, relating to water contracts, is that a State law is superior to city ordinances, city charter provisions, and the like. Various courts have held that no higher police duty rests upon a municipality than that of furnishing an ample supply of pure water. Several cases are cited where private water companies were required to extend their lines at the request of consumers.—*Lewis V. Carpenter.*

**Fire Protection in 31 New Jersey Cities.** ANON. Am. City. 53: 1:75 (Jan. '38). An abstract from a survey of fire fighting facilities made by the Bureau of Municipal Research of the New Jersey State Chamber of Commerce.

A description of how insurance ratings for a city are obtained and a table containing the population, insurance rating, per capita cost and budget for the fire department, and the '36 fire losses, are given for each city.—*Arthur P. Miller.*

**Bonded Debt of 286 Cities as of Jan. 1, 1938.** ROSINA MOHAUPT. *National Munic. Rev.* 27: 319 (Jun. '38). Questionnaires sent to the 310 American and 18 Canadian cities of over 30,000 pop. brought replies from 271 and 15 cities respectively. These are tabulated under gross bonded debt, sinking funds and net bonded debt, with per capita av. for latter. Totals and per capita given for four population groups, but for U. S. only. Similar tabulations have been published for many years past. Bonded debts continue the downward trend of last few years except that in the smallest cities slight increases occurred. For 243 comparable American cities totals for '37 and '38 were: Gross bonded debt \$5,600,000 and \$5,542,000; net, less self-supporting \$3,896,000 and \$3,829,267. Net per capita debt less self-supporting for the 269 American cities reporting for '38 ranged from \$389 for Atlantic City, N. J., to \$7.03 for Springfield, Ill.—*M. N. Baker.*

**Determining Population in Intercensal and Postcensal Years by Means of Continuous Population Registers.** DOROTHY S. THOMAS. *Am. J. Pub. Health.* 28: 28 (Jan. '38). The theoretical requirement for determination of population in intercensal years is continuous registration of births and deaths and of all persons establishing and giving up residence in the area. This requirement is met in Sweden, the Netherlands, and certain other European countries. The extent of cyclical variations on intercensal population, due largely to net internal migration, is shown for selected Swedish regions and their implications for computing vital rates are discussed.—*H. E. Babbitt.*

#### WATER SUPPLIES—GENERAL

**Chicago Filter Plant to be Started.** ANON. *Eng. News-Rec.* 121: 99 (Jul. 28, '38). Chicago City Council on Jul. 20 authorized sale of \$6,700,000 in water certificates to provide city's share of cost of starting work on South Side filtration plant. PWA will make grant of \$5,415,750, 45% of cost of project. Total cost about \$21,000,000. Certificates will be retired entirely from water revenues. PWA project includes installation of meters in South District. Plant will be constructed on filled land in L. Michigan at foot of 79th St. Will supply South District of city and 13 South Side suburbs which buy city water, population of about 1,700,000.—*R. E. Thompson.*

**Surface Water Supply for Houston.** ANON. *Eng. News-Rec.* 120: 818 (Jun. 9, '38). Consulting engrs. have recommended that Houston, Texas, water dept. be placed under control of appointed water board, that surface supply from San Jacinto R. be developed rather than expand present well system and that revenue be augmented by sale of water to industries which now have their own systems. Seven alternative supply systems were studied. Present supply is derived from 19 wells through 7 pumping stations scattered over city and pumpage is 25 m.g.d. (72 gal. per capita), which is only  $\frac{1}{4}$  of

water used in city. Water available is not sufficient for good service and fire protection: latter deficiency costs citizens \$180,000 annually in extra charges for insurance premiums. Other deficiencies include large proportion of small distribution piping and too few fire hydrants. If program is adopted, these would be corrected over period of 10 yrs. Principal pumping station has been submerged by floods twice in past 10 yrs. Annual revenue is only \$3.50 per capita. Initial San Jacinto development would consist of low weir-type dam to impound 9,000 mil. gal., pumping station and 10.5-mi. canal to 100-m.g.d. purification plant. Standby pumping station at present 15-mil. gal. Sabine St. reservoir would provide for fire protection in downtown area and 3 elevated tanks in west end of city would maintain pressure at times of heavy draft. If city could obtain contracts from industries as was done in Birmingham, Ala., whole project, adequate until '50, could be financed: otherwise, modified program with partial dependence on well supply until sales are built up is recommended. Under latter scheme, purification plant would only be of 50 m.g.d. capacity. New supply system would cost \$10,600,000 and water cost per 1000 gal. would be 6.8¢ and 4.1¢ in '40 and '50, respectively: present cost is 4.6¢. Substitution of pipe line for canal would increase initial cost \$1,913,000.—R. E. Thompson.

**Romance of a Midwest Waterworks.** ANON. Eng. News-Rec. 120: 407 (Mar. 17, '38). History of Marshalltown, Iowa, waterworks is reviewed and present operating practices outlined. Filter plant, constructed in 1876 to treat Iowa R. water, was one of first in Mississippi Valley: it consisted of a single 16' x 32' slow sand unit containing 24" of sand, 6" of charcoal and 6" of crushed rock supported on perforated wood bottom and operated at 3 m.g.d. (per acre?) rate. Plant was overloaded and turbidity clogged the filter badly: a second unit with porous terra cotta brick as filter medium was added, but clogging was worse than with the sand. Following high typhoid incidence, filters were abandoned in 1880 and water supply was successively derived from infiltration galleries, a spring and finally, in 1890, from wells which, with additions, are still the source of supply. An iron removal plant was later installed and a softening plant is now under construction which will reduce the hardness from 22 to 7-8 g.p.g. Old hydrants and valves being replaced as finances permit. Hydrants are inspected 2 or 3 times during winter, commencing in Oct. Meters originally owned by consumers, but in '32 all old meters were replaced without cost to property owners and cost of repairs is now borne by dept., with exception of damage by frost or hot water. Present bonded indebtedness, it is anticipated, will all be retired in '44. Softening plant is being built on pay-as-you-go basis.—R. E. Thompson.

**Revamping a Water System.** R. E. LAWRENCE. Eng. News-Rec. 120: 504 (Apr. 21, '38). Water supply of Leavenworth, Kans., derived from Missouri R., is treated by plain sedimentation and coagulation without filtration, no improvements of consequence having been made since plant was constructed in 1882-7. With raw water turbidities of 20,000 p.p.m. and higher not uncommon, quality of finished water is at times far from satisfactory. This has resulted in loss of 2 large institutions as customers and consequent reduction

in revenue. Possibility of losing other institutional users rendered imperative modernization of the works, and financial problem was complicated by fact that peak of debt service requirements of bonds issued to acquire system in '21 occurs over next 4-5 yrs. Water works board was elected to assume complete charge of system and rehabilitation program is now underway which includes essentials necessary to render supply satisfactory, less important improvements being deferred until finances warrant additional expenditures. Immediate program consists of installation of new intake (rendered necessary by federal channel stabilization activities) and low-service pumping station, a modern 4-m.g.d. filter plant and high-service pumping station, and flooring and covering for existing 5-mil. gal. high-level reservoir. Present settling and coagulation basins will be retained and secondary mixing chamber and small reaction basin added. Plant is being designed to permit adoption of softening when finances permit. Population of city is 17,500 and max. consumption slightly more than 3 m.g.d.—*R. E. Thompson.*

**Water Works Improvement Program at Vancouver.** J. L. HENDERSON. *W. Cons. News.* 13: 186 (May, '38). Rehabilitation program of Vancouver, Wash. being pushed; includes installation 11 mi. of c.i. 6" to 20" pipe, erecting new 100' high, 250,000 gal. elevated tank, drilling 2000 g.p.m. well and construction of 4 mil. gal. concrete timber-roofed reservoir. Program planned for growth in pop. by 1950 from present 22,000 to 40-50,000. Existing water supply from wells and springs; plans call for abandonment of springs and taking entire supply from wells. The c.i. pipe being installed will raise percent this type pipe in system to 30%. 213 services added in '37, total at end of year being 5198; av. mo. income being \$8500.—*Martin E. Flentje.*

**The Water Supply System of Windsor, Ont., has Many Unusual Features.** ANON. *Eng. Cont. Rec.* 51:12:15 (Mar. 23, '38). The 4 separate communities referred to collectively as the Border Cities were amalgamated in '35 and the new Windsor Utilities Comm. now controls the entire supply in the enlarged city and in suburban districts, area and population served being 41 sq. mi. and 115,000, respectively. History of the supply is outlined. Present intake consists of 4' steel pipe extending 500' into Detroit R. and terminating in 35' of water, rated capacity being 63 m.g.d. Complete blockage of intake with frazil ice has occurred 11 times during 12 winters. This condition is combated by reversing flow through intake, provision for this operation having been made when plant was designed. "Over and under" type mixing basins provide 8 min. mixing prior to 2-hr. detention period in settling basins. Alum dosage ranges from 0.15 to 5.0 g.p.g. Max. turbidity permitted in water applied to filters is 25 p.p.m. When raw water turbidity is less than 25 p.p.m., alum is added intermittently, i.e., 40 min. in each hr. Ammonia and chlorine (0.25 lb. of former and 1.5-3.0 lbs. of latter per mil. gal.) are also applied prior to filtration, filter effluent having a residual chlorine content of approx. 0.06 p.p.m. There are 10 gravity filters, each 700 sq. ft. in area, rated capacity of plant being 21 m.g.d. Underdrains are of c.i. pipe and filter beds consist of 36" of sand with effective size of 0.45 mm. and unif. coeff. of 1.5 and 15" of gravel varying in size from pea gravel up to 2". Filtered water storage is 2.3

mil. gal. During '37, most probable no. of coliform organisms per 100 cc. was reduced from 56.69 in raw water to 0.18 in filtered water (prior to post chlorination). Av. length of filter runs was 30.5 hrs. Rate of filtration ranged from 96 to 129 m.g.a.d. and averaged 118. Washing procedure is as follows: primary expansion 15 sec., scrubbing action at  $\frac{1}{2}$  full expansion (10" rise) 4 min., secondary expansion 15 sec., cleansing action at full expansion (18" rise) 4 min. plus. There are 2 pumping stations, of 37 and 16 m.g.d. capacity, respectively. As secondary line of defense, chlorine is applied at both stations in sufficient amount to maintain not less than 0.2 p.p.m. residual in water entering distribution mains. There are virtually 2 separate distribution systems, connected by 2 normally closed gate valves. Practically all services are metered. Domestic meters are serviced every 5 yrs. and large commercial meters are checked every yr. Customer accounting system used is combination bill and ledger plan, using a Burroughs utility billing machine. Water rates are made up of a service or demand charge which varies according to size of meter, fire protection charge of 1.5 mills on assessed value of property, multiple service charge where meter serves more than one apartment or dwelling and frontage charge of 7¢ per ft. General rate, computed quarterly, is 6¢ per 100 cu. ft. where consumption is over the 1500-cu. ft. allowance for  $\frac{1}{2}$ " meters and the 2000-cu. ft. allowance for all other sizes, which amounts are included in quarterly min. or demand charge. Cycle plan of billing is employed, accounts being billed quarterly except those served by large meters, which are billed monthly.—*R. E. Thompson.*

**Northern Growth Requires New Pumping Station.** F. G. BROWNE. *Can. Engr.* 74:18:8 (May 3, '38). Within boundaries of Township of Teck, Ont., are situated 2 towns, Swastika and Kirkland Lake, and the area which in past 2 decades has become famous as one of richest and largest gold-producing areas in world. As result of latter development, population has increased since '26 from under 4,000 to approx. 20,000 and water consumption from about 0.25 to about 5 m.g.d. Water works system, installed in '24, derived its supply from Gull Lake. Later, to augment supply, pumping station was constructed at McTavish Lake to pump water from latter through 30" pipe line, 19,800' long, into Gull Lake, which was converted into a reservoir for the local station. Although elev. of McTavish Lake is only 27' lower than that of Gull Lake, rough and rocky terrain and range of hills between them makes it necessary to pump against head of 161'. With increasing demand and original Gull Lake station extended to limit of location, construction of new dam and forebay and station was commenced in '35 in ravine immediately northwest of existing station. Three new pumping units were purchased and set up in new station and old units transferred without interruption to supply. Service pumps are electrically driven and standby units are driven by gasoline engines. Cost of station, including new pumps, was \$64,816.—*R. E. Thompson.*

**The Extra ordinary Low Water Levels of the La Plata River.** L. IVANISSEVICH. *Bol. Obras Sanitarias Nacion* (Buenos Aires). 1:479 (Nov. '37). The extraordinary low tide of Oct. 9, '37, which uncovered the Buenos Aires water intake gates for twelve hours, was the most serious, although not the worst, of the three lowest low water levels of the La Plata R. since 1869. (See ab

stract J.A.W.W.A. 30: 194 (Jan. '38)). Due to the low temperatures, rainy weather and smaller water consumption at the time of the '20 and '29 low tides, it was possible to maintain continuous service with the water stored in distr. reservoirs. The emergency created by the complete interruption of service in '37 has prompted the study of three major projects for the prevention of its recurrence. The idea of extending the intake into deeper water at an estimated cost of 50 million pesos and that of sinking wells with capacity to supply the city at a cost of 30 million pesos plus increased pumping costs have been discarded for a more economical project involving the construction of reinf. concrete raw water reservoirs on the river bed in front of the filter plant. These reservoirs, which will have ample capacity to supply the city through an emergency worse than that of '37, will be provided with inlet gates at various elevations in order to admit the river water at the higher stages and retain it at low tide thus reducing the average pumping lift and insuring a continuous water supply.—*J. M. Sanchis*.

**The Transition from Surface to Ground Water in the Altona Supply.** C. JÜRGENSEN. Gas-u. Wasser. 80: 566, 585 ('37). The author gives an historical account of the water supply of Altona and then describes the construction of the various wells by means of which between '29 and '36 a ground water supply was substituted for the original supply from the Elbe. Water from wells to the east of the town is treated in the filtration plant originally designed for Elbe water and a plant for deacidification and removal of iron and manganese has been constructed to treat water from wells in the west. The geology and construction of the wells, the composition of the raw water, the pumping plants and the treatment plants are described.—*W. P. R.*

**Water Supplies in Austria.** PAUL WESTHAUSER. Gas-u. Wasser. 81: 466 (Jun. 18, '38). About 80% of the potable water obtained from springs and about 20% is ground water. Surface water not used at all. Only a few small plants use softening or iron removal processes. Most cities, including Vienna, are supplied directly with untreated spring water. This is possible owing to (1) geologic conditions (large glacial deposits), (2) high precipitation, much of which falls as snow, (3) timber-land that covers 40% of the area, (4) lack of industrial stream pollution and (5) lack of mining that lowers ground water levels. About 60% of total population of 6,700,000 is supplied by central water supplies. Av. consumption about 27 gal. per day per capita. In Vienna with pop. of 1,800,000 the av. consumption is 37 gal. per day per capita. Water plants are either owned municipally or by corporations. Prices for water vary between 7.6 cents to 66 cents per 1000 gal. Many communities still require central water supplies but have to depend on outside help. Need is suggested of forming a central office that should collect all data relative to water supplies, make further investigations thereof, develop economic planning and recommend construction. Such an office could be financed by small pro rata contributions of the water works. It would be of great value for the further economic development of the water works and water use.—*Maz Suter*.

**The Pumping Plant of the Jerusalem Water Supply.** ANON. Engineering (Br.) 145: 575 (May 20, '38); also The Engr. (Br.) 165: 516 (May 6, '38); also

Wtr. and Wtr. Eng. (Br.) 40: 371 (Jul. '38). Brief, but interesting, history is given of the developments which led to the construction of the present works, the plan for which was approved in '33. Supply is taken from wells at Ras-el-Ain springs at the head of the Auja R., 37 mi. from Jerusalem and 2,750' lower than the city. Three 10' wells were sunk to depths between 30' and 40' to give combined yield of 500 g.p.m. (Imp.), supplemented by a "collector" consisting of a well 30' dia. and 13' deep fed by radial concrete feeders 2' dia., which increased the supply to the 1.34 m.g.d. (Imp.) required. The permanent installation at Ras-el-Ain now consists of a pumping station and a sterilization, softening, and filtration plant. Latter has a capacity of 1.5 m.g.d. (Imp.) with an ultimate capacity of 3.3 m.g.d. (Imp.). There are three intermediate pumping stations on the 18" pipe line to the city, including intermediate reservoirs. Distances and heights pumped by each station are: Ras-el-Ain, 22 mi. and 75'; Latrun, 5.5 mi. and 650'; Bab-el-Wad, 3 mi. and 800'; and Saris, 10.5 mi. and 800'. The final reservoir is 2850' above sea level. That portion of the pipe line with pressure heads less than 200' is centrifugally-cast iron pipe, remainder is steel. The reservoirs are of reinforced concrete with earth embankment. At the Ras-el-Ain pumping station 3 sets of main pumps are provided, only 2 of which are necessary for present requirements. The pumps are 9-stage, centrifugals capable of delivering 800 g.p.m. (Imp.) at a total head of 850'. They are driven by Diesel engines. In addition there are 3 electric generators, each delivering 28 kw. at 200 volts; the current being used for operating motors which drive the single-stage well pumps.—*H. E. Babbitt.*

**Durban's New Water Scheme.** ANON. The Engr. (Br.) 165: 318 (Mar. 18, '38). Durban's new water scheme (S. Africa) will supply 20 mil. gal. (Imp.) daily, in addition to the present supply, at an estimated cost of £1,750,000. The new Umgeni impounding reservoir will have a capacity of 5 billion gal. (Imp.) The dam will be situated at the foot of Table Mt. (Natal), 32 miles from Durban. In construction of the dam river will be diverted to a point about 2,000' below the dam, leaving site of the work dry. Diversion channel will be 100' wide at the base, 1,300' long, and 85' deep; the flow in it being controlled by mechanically operated gates. Weir at head of the impounding reservoir will divert flow into the reservoir or into the diversion channel. The water from the reservoir will be conveyed to the city through an aqueduct for 32 mi., including 1.24 mi. of tunnel.—*H. E. Babbitt.*

#### DISTRIBUTION MAINS AND RESERVOIRS

**Welded Steel Pipe for the City of Toronto Water Works Extension.** CARL R. WHITTEMORE. Eng. J. (Eng. Inst. Canada) 21: 331 (Jul. '38). Describes in detail the design, fabrication and installation of approx. 38,380' of 48" diam. concrete lined all welded steel pipe. Introductory paragraphs give brief resumé of water-carriers from tenth century B.C. to the present. A brief outline compares merits of different types of modern pipes. Pipe fabricated in 12, 18 and 30' lengths from plate 6' wide, rolled with the 6' dimension parallel to pipe axis, thus giving a circumferential arc welded joint every 6'. Straight pipe sections are centrifugally concrete lined, specials, bends and field joints

lined with gunite. A school was established for welders, attention being paid to manner in which welds may fail and types of failures; these are enumerated. Concrete lining  $1\frac{1}{2}$ " thick reinforced with wire mesh, retained proper distance from pipe shell by  $\frac{1}{4}$ " diam. steel spacing wire. Pipe cylinder is 51" i.d. Air valve connections, Victaulic couplings, manholes and flanges are cast steel designed for butt welding to the steel shell. Automatic welding used in making longitudinal and circumferential seams;  $\frac{1}{4}$ " bare metal electrodes in coils with regulated supply of flux. In longitudinal seam welds the pipe section remains stationary, the welding mechanism travelling at predetermined speed, while in welding the circumferential seams the flux hopper and welding head remain stationary and the pipe section revolves. The outstanding properties of centrifugally spun concrete are smooth finish, high compressive strength, and high density. It has been shown that the wear is inversely proportional to the strength. Concrete lining specified as follows; 1 part Portland cement, 1.93 sand, and 1.36 stone, measured by volume loose and uncompacted, with approx. 4 gal. of water per sack of cement, regulated to give approx. 3.5" slump. After curing pipe is delivered to trench side by truck equipped with cushioned bunks, unloaded by crane, laid and welded field joints made. Pipe line is encased in concrete having min. thickness of 4". Seven and 28 day compressive strengths of lining are tabulated; details of welds are illustrated by figures; and certain processes in pipe fabrication are reproduced by photographs.—*Samuel A. Evans.* This article gives much detail regarding welding and lining methods. See also abstracts J.A.W.W.A. 30: 706 (Apr. '38) and 30: 1250 (Jul. '38).—*Ed.*

**Submerged River Crossing at Augusta, Maine.** S. S. ANTHONY. J.N.E. W.W.A. 52: 58 (Mar. '38). To insure water service to east side of city in emergencies 760' of 16" Universal, Type T, 250 lb. working pressure, pipe lined with  $\frac{1}{4}$ " thick cement was laid across Kennebec R. supplementing other older lines. Pipe laid in trench in river bottom; where ledge rock was encountered min. cover was 4', where no ledge appeared min. cover was 6'. Cost of job approx. \$85,000.—*Martin E. Flentje.*

**Steel Pipe for Water Mains.** E. H. THWAITS. J.N.E.W.W.A. 52: 93 (Mar. '38). The more than 33 mil. ft. of steel water pipe installations show satisfactory service records up to 86 yrs. For oil and gasoline transportation 115,000 mi. steel pipe used; 70,000 mi. for natural gas; entire gas industry with much of its 266,400 mi. of gas mains of steel pipe. Steel pipe is strong, tough, flexible; yields high initial and sustained flow cap.; is "bottle tight" when assembled; needs no consideration for "breakage factor" in design, construction or maintenance; is economical because of few joints and ease of laying. Unlined steel pipe with continuous interior has av. Hazen-Williams "C" value of 140. Unlined 8" steel main will have same av. carrying cap. after 48 yrs. service that ordinary 8" main will have at end of 16 yrs. service; 12" main same in 45 yrs. as ordinary 12" in 17 yrs. With good coal-tar base enamel, "C" value of 150 can be maintained throughout life of pipe. Use with mech. type couplings and in long lengths, reduction in number of av. joints per mi. is from 440 for 12", 330 for 16" with ordinary pipe to 130 couplings for

av. 40' lengths steel pipe. Laying and field costs reduced 15-25%. All ferrous pipe materials corrode at nearly same rate under same soil conditions, therefore necessary to make soil analyses to detn. nature protective coating req'd. Application of modern pipe protection materials should eliminate tuberculation entirely and decrease soil corrosion to min. Present day coal-tar-base enamels give most effective economical corrosion protection. Process of plasticizing coal-tar pitches allows production of pitches that are not self-cracking over wide temp. ranges as low as  $-40^{\circ}$  F. and with no sag at  $200^{\circ}$ - $250^{\circ}$  F. Predicted there soon will be no more unlined pipe used. Tapping in steel pipe carried out with pipe saddles or with expanding ring and expanding bushing.—*Martin E. Flentje.*

**Reinforced Concrete Pipes for High Pressure Service.** L. W. HAASE. *Gesundheits-Ing.* 61: 276 (May 14, '38). Method is described that allows manufacture of concrete pipes with prestressed reinforcing which can carry high inside pressure without producing tensile stresses in the concrete. These pipes made in a machine that allows application of inside and outside pressure during hardening. The reinforcing is set and the concrete poured around it with shaking of the rubber covered forms. Ordinary portland cement and concrete mix of 1:3.5:4 is used. Openings are then closed and outside pressure applied which removes excess water. Concrete is then heated to  $70^{\circ}$  to  $90^{\circ}$  C. and a high hydraulic inside pressure is applied. This produces a tension in the steel spiral reinforcing which can reach 60,000 lbs. per sq. in. The concrete sets in two hours and the pipes are then ready for use. Pipes have been made to withstand as much as 1600 lbs. pressure. They are made 24" and larger and in lengths of 20'. Wall thickness is  $1\frac{1}{4}"$  to 2". These pipes have no bells and are connected by outside rings.—*Max Suter.*

**The Requirements in Iron for Connection of Residences to the Public Water Supply.** HANS FAENDRICH. *Gas-u. Wasser.* 81: 500 (Jul. 2, '38). Calculates how many pounds of iron are required in the distribution system per family residence with different types of housing. Generally only 4" pipe in the street and 1" to  $1\frac{1}{4}"$  connection to the basement are considered; some data on 6" mains also given. In open housing different conditions are considered, such as houses for one or two families and different widths of lots and streets (including front yards). In closely built up districts houses from one to four stories are considered. Depending on these conditions it is shown that in open housing districts 160 to 3350 lbs. of iron are required per family residence, whereas in closely built districts only 51 to 344 lbs. Considerations are discussed which will tend to reduce consumption of iron in future planned open settlements.—*Max Suter.*

**Hydrant Connections and the Control of Dual Mains.** ARTHUR F. BALLOU. *J.N.E.W.W.A.* 52: 81 (Mar. '38). The traditional arrangement of dist. system consisted of one main in each street, cross-connected with other mains for mutual delivery strength; now being changed in some cities by installation of 2 mains in street—one for general distribution under sidewalk and other, frequently of smaller diam., under opposite sidewalk to care for consumers

services on that side of st. Second line sometimes treated as a main line, other times as service header, and in this case extends under walks half-way around block to connection at other end with intersecting main. A break in older type typical dist. system main, in which laterals and arteries cross connected by 4 way fitting with 3 valves in lines and hydrant off branch with valve in branch, required 2 to 4 valve shut downs and taking out of service or dead-ending 1 hydrant, and 10 to 16 services. Simplification achieved by connecting artery to lateral through 2 tees and short run of pipe with valve at each connection and hydrant tee taking off between these valves. In main break in simplified system no hydrant will be taken out of service and no temporary dead-ends created improving reliability of hydrant service and adequacy of local distribution. If to this scheme be added smaller service header under opposite sidewalks, max. number of services affected by break will be cut in half or if max. service affected by break under old system not considered excessive, fewer main line valves can be used which may result in as much as 25% savings over traditional plan. As valves eliminated include larger sizes plan may also commend itself as reducing material costs, annual inspection and maintenance charges. [Proposed system clearly shown in diagram given in article showing mains, connections, hydrants and valves required in area of 9 sq. city blocks.]—*Martin E. Flentje.*

**Water Wastage: Cause, Detection and Prevention.** J. ARTHUR RODWELL. Surveyor (Br.) 94: 5 and 2 (Jul. 1, '38). *From paper before British Waterworks Assoc.* "Waste" comprises water which has been lost by leakage from mains, service reservoirs, distributing pipes, services, defective fittings, and other apparatus; that is, which has been unproductive of revenue. Wilful negligence in its prevention, on private property, is a penal offence. Preventable waste has in a number of cases exceeded amount actually used for domestic purposes. Our present haphazard method of forming an estimate of domestic consumption by deducting amount taken by metered supplies from bulk amount drawn from source, and referring to the residual as "amount used for domestic and public health services, inclusive of waste" is unsatisfactory. In detection of waste some form of metering is essential on trunk and distribution mains. Various forms of waste-water meters are available including the Deacon, Venturi, Orifice, and Pitot tube. Leakage can be ascertained by comparing normal flow with that when sections of main or distributing pipes are cut off. Such tests should be followed by localized leak detection by sounding rods, and other instruments. Pressure gages connected to a main are useful and dependable for tracing leakage. Leakage from a service reservoir can be detected through comparison of inflow and outflow, or by noting loss of water level with all valves shut. Service pipe leakage can be detected by sounding at the corporation cock. Accurate maps of the distribution system are essential in a waste survey. The location of "lost" pipes and fittings is easily accomplished by the wireless pipe locator. Growing use of reinforced concrete in highway construction makes it imperative that mains be laid at side of road. Devices used in detection of leaks include the sounding bar, electrical sound amplifying devices, devices to reveal the hydraulic gradient, and the principle of water

hammer. Prevention of waste is accomplished through repair of leaks; the regulation of pressure by "zoning" areas in distributing systems; the free re-washing of consumers' water taps; and prohibition of use of inferior fittings. No satisfactory automatic water-saving apparatus, such as a self-closing tap, has yet been devised. Modern house design is conducive to water waste through need for running water a long time to get suitable temperature, either hot or cold. General tendency to be extravagant in household use of water. Cost of water steadily rising. Metering of all supplies has gone far to reduce thoughtless consumption without endangering health of the community. As a preventive of waste the value of metering is obvious.—*H. E. Babbitt.*

**The Geophone as Apparatus to Listen to Water Distribution Systems.** *WALTER EBNER.* *Gas-u. Wasser.* 81: 532 (Jul. 16, '38). Several types of geophones are described and experiences given in their use for detection of leaks in water mains. Influence of different types of soils and pavements discussed. Highly sensitive electrical apparatus not considered useful as it registers too many outside noises. In Stuttgart preliminary location done during the day with simple hand apparatus; the exact location is determined after midnight with more sensitive equipment. Success in finding the correct location was had in 95% of the cases.—*Max Suter.*

**Listening Rod Locates Leaks.** *GEO. A. FORNER.* *Eng. News-Rec.* 121: 93 (Jul. 21, '38). Leaks may be located without excessive excavation by determining approx. location by ground dampness, pneumatically drilling holes down to pipeline several feet apart, inserting steel rod in each hole to contact with main, and listening for hum, which increases or decreases with proximity to leak.—*R. E. Thompson.*

**Relining an Elevated Storage Reservoir with Gunite.** *ROGER W. ESTY.* *J.N.E.W.W.A.* 52: 31 (Mar. '38). Experience is given in relining 1,678 mil. gal. cap. Wills Hill Res. of Danvers, Mass. Finished at actual cost of \$14,-910.62, leakage tests indicated job 100% watertight. Actual working time was 53 days, 2069 bags cement used, 275 cu. yd. of sand, 30,770 sq. ft. of 4" x 4", No. 6 by No. 6 wire, and 29,742 sq. ft. actual area covered. Av. depth of Gunite was 2½", with extremes of 1½" to 4"; mixture used was 1 part cement and 3.5 parts sand. Board well pleased with results.—*Martin E. Flentje.*

**A Subterranean Reservoir at Billings, Montana.** *A. L. HEWETT.* *Pub. Wks.* 68: 11:15 (Nov. '37). The location of a suburban district above the reservoir serving the city of Billings, Montana led to construction of a unique pressure system. A storage reservoir was built by driving a tunnel into a ledge of rock above the district and excavating a spherical hole 33' in diam. The reservoir so excavated gives a minimum pressure of 91 lbs. per sq. in. in the upper part of the area served. A roof of solid rock above the reservoir 55' thick and a minimum thickness of 55' between reservoir and face of ledge would seem to eliminate any chance of freezing during the extreme low temperature had in

winter months. Booster pumps used in connection with this and a second and higher district are arranged for automatic operation and located in a pit that is entirely safe from freezing.—*P. H. E. A.*

**The Leaching Out of Lime from Concrete.** T. A. SHANN. *Bautenschuts* 7:9:105 ('36). *Bldg. Sci. Abstracts* 10: 12 ('37). Results of expts., in which specimens of permeable cement mortars were exposed to action of distd. water, show that amt. of lime dissolved out in this manner gives no reliable indication of resistance of a cement to action of soft water. Cements with excess of lime exhibit greater loss but reduction in strength is not so great. A special Swedish cement for hydraulic structures with relatively low lime content displayed same proportional loss of strength as ordinary portland cement. Porous mortars of high alumina cement are also attacked by soft waters in spite of their low lime content: alumina and Fe compds. go into solution, causing rapid loss of strength.—*C. A.*

### METERING

**Introduction of Universal Metering at City of Lyon, France.** ROGER GIRARD. *Technique Sanitaire* (Fr.) 32: 2 (Jan. '37). Lyon is a city of great antiquity where age old customs are changed with difficulty. (Population approx. 580,000). Long established usage was to pay a flat rate for each faucet on the premises. Supply of excellent water is available from alluvial deposits of the Rhone Valley, but nevertheless, an acute emergency arose partly from increased consumption and still more from increased cost of electric power commencing about '20. In that year power cost for pumpage was 275,000 francs, in '31 it reached 3,150,000 francs, increase of nearly 12-fold in 11 yrs. Increase in power consumption was only from about 16,500,000 to 23,900,000 kw. hr., or less than 50%. In Sept. '31 on the motion of the celebrated Mayor of Lyon, M. Herriot, the municipal council decided upon universal metering to impose a check upon a situation which was rapidly becoming impossible. Result has been that in '34 cost of power had been cut to 1,890,000 francs and power consumption to 17,500,000 kw. hr., notwithstanding an increase in the meantime of 18,000 in number of services. In same period daily pumpage had dropped from 62 mil. gal. in '31 to 42 mil. gal. in '34. Many other accompanying savings also accomplished. Until '30 metering had had but few advocates among water authorities in Lyon. The presence of very fine sand in the water caused volumetric meters of the type approved in Paris, and which had first been experimented with, to choke rapidly. Volumetric meters had therefore been prohibited in Lyon and the few existing meters were of velocity type. Two-thirds, or about 100,000, of the services in Lyon consisted of a single sink faucet. The first step in general metering was therefore to provide small meters combined with the faucet in a single unit. Almost at once a serious difficulty arose when it was found that even in the kitchen about 5% of these meters were frozen in winter. It became necessary to devise a frost-proof meter system. This was done by introducing just ahead of the meter a three-way cut-off valve through which the meter empties into the sink when the valve is closed. Article gives details and illustrates the valve and also many provi-

sions against possible fraudulent practices. A similar anti-freezing device had to be designed for meters inserted on services in the ordinary way, of which full details also are given. Before constructing the meters studies were made as to most favorable dimensions and materials, also as to protective coatings. Believed that Lyon meters were definite advance on any before in use. They are rugged and require little attention. When used only at rare intervals they do not clog or seize. Expected that they will last many years without loss of accuracy. Author goes on to describe how they were faced with problem of deciding upon size of meter to use in each case. He characterizes the capacity of a meter in two ways; either (1), its peak capacity, i.e., amount of water which it passes during one hour at a constant loss of head equal to 20 meters (65 ft. = 28 lbs. per sq. in.), or (2), the average amount of water per day which it can pass over long periods without abnormal wear or loss of sensitivity or precision. The latter capacity can only be determined from successive readings in actual practice. Based on experience in Lyon a table is given of different sizes of meters and their respective peak capacities and ordinary capacities, from which it appears that the former rate is in every case about 14 times the latter. Found that on premises with but a single faucet daily consumption seldom exceeds 300 liters (80 gal.) which is about peak capacity for 1 hr. continuous flow. The greater the number of faucets in use the more will the mean daily consumption and peak daily consumption fall short of the sum of the 1 hr. peak consumption of the several faucets. It is clearly the peak rather than the mean which determines the size of the meter. The 1 hr. peak capacity of a meter is therefore its most important size-determining characteristic except that of course a meter of any given size could not take care of a mean daily consumption any greater than its specified average for continuous use. Hence right is reserved to call on user to install a larger meter when his consumption between readings is abnormally high. Next point was to determine what should be the normal peak consumption where there were a number of faucets and not all of same size: the meter size for such a combination should be such that its peak capacity is just greater than the normal peak consumption, always provided that the available pressure is 20 meters (65 ft. = 28 lbs. per sq. in.). As a rule, owing to the vertical height of the faucets above street level, the available pressure will be less. If  $Q$  be peak flow in liters per hr. which it is desired to secure, and  $H$  the height in meters of the faucet above street level, then the meter must have a peak capacity in liters per hour of at least

$$Q_H = Q \sqrt{\frac{20}{25 - H}}$$

In order to determine the peak demand on domestic premises, the various draw-off points are classified as exact multiples of the single sink faucet, 300 liters (80 gal.) per day, taken as the unit. A wash basin is for example taken as two units and a bath as three. The probability of simultaneous functioning of the several draw-offs as a function of their number and their size was next considered and the following rules were derived:— (1) add the number of orifices (i.e., draw-offs), (2) assign to each its value in units as above outlined

and add together to obtain the total number of units. It has been found by experience that  $q$ , the domestic peak on a single premises in cubic meters per hr., where  $n$  is the number of orifices and  $N$  the sum of their unit values, is given by the formula:

$$q = 0.3 N \frac{2n}{N+n}$$

This formula cannot be extended as it stands to cover a group of premises, the peak for which is a fraction only of the sum of the peaks of each. If  $(k+1)$  be the number of premises and if  $q_1, q_2, \dots, q_{(k+1)}$  be their respective peaks, the peak  $Q_{(k+1)}$  in cu. meters per hr., of all taken together will be given by

$$Q_{(k+1)} = \frac{20+k}{10(2+k)} \times \Sigma q = \frac{20+k}{10(2+k)} \times \sum_0^{(k+1)} 0.3N \frac{2n}{N+n}$$

The peaks and average daily consumption of industrial premises cannot be determined thus; each must receive individual consideration. Studies are on foot towards introduction of a new type of meter, in which peak hourly flow and maximum allowable daily flow will not differ greatly in value; which will be suitable for industrial premises which as a rule need meters of not less than 30 mm. ( $1\frac{1}{8}$ " ) size, and will enable the rules for determining meter sizes to be completed. The formula for a number of premises can be applied equally to the increase of the number of apartments in an apartment building, where pipe sizes must be adjusted to meet the loss of head as the vertical height increases. Nomographs (of which five are reproduced in the article) for solving these and related problems have been constructed for use of the water service personnel. Method has been introduced in similar principle for calculating necessary sizes of mains, etc., (see author's "L'Alimentation en eau de Lyon") one example of which is given. If  $l$  be the width in meters of a public highway serving a "hinterland" of  $L$  meters on either side, and if ratio of area built on (including interior courts) to total area of private properties be denoted by  $s$ , and if the buildings in question have (on average)  $h$  stories, then the daily consumption of water,  $C$ , in cubic meters per 100 meters of highway will be given by

$$C = 1.2 \sqrt[10]{h^4 s^3} (l \times L \sqrt[10]{h^4 s^3})$$

where the first term represents the public consumption and the second term the private. [The nomograph illustrated in the article effects the solution of this complicated looking expression quite simply and promptly.] Very interesting results are obtained by applying the above formula on a large scale. It will at once appear that the domestic peak consumption per hectare (10,000 sq. m.) should vary from 1 cu. m. per hr. in thinly populated sections to 50 cu. m. in densely populated areas (under conditions usually found at Lyon). The calculation is given. Other interesting results are given and as a final test of the formula it is applied to the 150,000 premises connected to the entire Lyon supply, the result then obtained, 15,000 cu. meters per hr., being not very far from the truth.—*Frank Hannan.*

**Meters in Minneapolis.** W. W. DeBERARD. Eng. News-Rec. 120: 578 (Apr. 21, '38). Five yrs. ago, meter dept. of Minneapolis was housed in new bldg. and meter handling procedure was modernized and record keeping revised and simplified. Present practice described in some detail. Customers own and are responsible for meters and must pay for repairs, although work is done by dept. Meters are read quarterly on continuous schedule, readings being recorded from bottom of page up and immediately subtracted. Meter pulling is arranged to dovetail with reading program. About 60 meters go through shop every day. Av. cost per meter in '36 was \$4.03. If repair cost is too high, customer is notified that new meter must be purchased from dept.—R. E. Thompson.

**Percentage of Services Metered.** ANON. W. W. Inf. Exch., Canadian Sect., A. W. W. A. 2:C:5:22 (Dec. '37). Tabulation is given showing, for Canadian municipalities, the no. of services, no. metered and percentage metered, classified as follows: industrial and commercial, domestic, and all services. Of 89 communities for which data are given, 100% of industrial and commercial services are metered in 40 and 100% of domestic services in 20. In the 87 municipalities for which percentage of total services metered is available, the av. percentage is 42.8. In these communities there are 1,164,166 services, of which 199,583, or 17.1%, are metered.—R. E. Thompson.

**Lubrication for Water Meter Registers.** ANON. Eng. News-Rec. 120: 549 (Apr. 14, '38). Corrosion in water meter registers was a problem in Los Angeles until special grease and means of greasing was devised. Rubber bushings for spindle bearings are placed in both top and bottom plates of register and the "dust ring" is used as a grease retainer. Specifications for the grease are as follows: "Pale or neutral mineral oil, pour test not to exceed 150°F. Viscosity 400 sec. min. at 100°F. (Saybolt Universal Test). Aluminum soap—10.5 to 11.5%. Melting point, 185 to 195°F. Grease shall not emulsify in water and shall contain no free caustic or lime." Greasing is effected with homemade grease gun, which is described. Only sufficient grease to completely surround entire gearing between top and bottom plates and the register casing ring should be used. One lubrication lasts until meter comes into shop for repair. Considerable saving has been effected.—R. E. Thompson.

**Twenty-One Things Can Happen to a Water Meter.** S. T. ANDERSON. Am. City. 53:4:57 (Apr. '38). The meter shops of Springfield, Ill. care for about 20,000 meters. When faulty meters are found by meter men or reported by customers, a service order is sent to the Service Shop by the Customer Accounting Division. The Service Section replaces the meter and sends the defective one to the repair shop with a three-part record tag. All meters, new or old, are tested and 2% deviation only is allowed. Details of testing are described. In repairing meters, they are taken down to the last nut, thoroughly cleaned, inspected and worn parts replaced. After repair, they are retested. The forms used are illustrated and described together with the methods of use.—Arthur P. Miller.

**An Insulated Water Meter Connection.** ANON. Eng. News-Rec. 121: 109 (Jul. 28, '38). Complaints of cloudy tap water in Los Angeles believed due to formation of zinc salts by reaction of carbonates and dissolved oxygen with galvanized pipe. This action greatly accelerated by electric current such as might result from cell formed by contact of galvanized pipe with copper service pipe. Electrical separation of 2 pipe systems reduces formation of zinc salts to min. To make such separation possible, meter connection developed containing sleeve or tailpiece that entirely insulates 2 sides of coupling. Placed at outlet of meter, it is made in 2 sections: one screws on meter spud, other slips over consumer's pipe and is thoroughly insulated therefrom by piece of hard vulcanized rubber tube 1" long and  $\frac{3}{16}$ " thick. Semi-hard rubber ring is first slipped over consumer's pipe and 2 sections are then screwed together, rubber ring being squeezed tightly around pipe, making joint water-tight. To facilitate sliding insulated section and rubber ring along pipe when removing or changing meter, smooth round 6" pieces of galvanized pipe are made up threaded at 1 end and equipped with galvanized iron pipe socket on which pipe wrench can be placed when making connection to avoid marring galvanized nipple.—R. E. Thompson.

**Tamperproof Meter-Box Covers.** ANON. Eng. News-Rec. 120: 585 (Apr. 21, '38). Brief description of concrete cover with c.i. seat for centerpiece, designed for Los Angeles system. By means of 2 slots in top rim of seat and corresponding lugs on centerpiece, latter is wedged securely in place by one-quarter turn, key being required for its removal.—R. E. Thompson.

**One Way to Steal Water.** ANON. Eng. News-Rec. 120: 586 (Apr. 21, '38). Bypassing of meter by tee connection installed with tee down, thus giving appearance of coupling from above, was found when excavation was made to investigate low consumption in establishment served with 1½" service.—R. E. Thompson.

#### BACTERIOLOGICAL

**The Occurrence and Succession of Coliform Organisms in Human Feces.** L. W. PARR. Amer. J. Hyg. 27: 67 ('38). An examination was made of 235 stools from 100 persons, 194 adults and 41 from infants. A saline suspension was plated on Endo agar and on Simmon's citrated agar. A variable number of colonies were picked; 4,837 colonies were tested only for their ability to utilize citrate as their sole source of carbon, while 1,987 purified strains were studied thoroughly. Sixteen samples showed no coliform organisms on plating; 11 of these (4 adult and 7 infant) failed to yield coliform organisms even after enrichment. *Esch. coli*, defined as an indole +, M. R. +, V. P. —, citrate — organism, was found in 218 specimens; intermediate organisms, i. e. M. R. + V. P. —, citrate +, were found in 51 specimens; *Aer. aerogenes*, i. e. M. R. —, V. P. +, citrate +, was found in 66 specimens; and *Aer. cloacae*, i. e. M. R. —, V. P. +, citrate +, gelatin liquefaction +, was found in 21 specimens. It may be noted that 7 of the 11 samples showing no coliform organisms came from young babies. Of the 4 remaining samples, 2 contained

large numbers of enterococci, one consisted of a pure culture of paracolon bacilli, while the fourth gave practically no growth on the media used. Other workers have reported finding stools free from coliform bacilli; among them may be mentioned one worker who found a stool to contain an apparently pure culture of typhoid bacilli. Among the 224 samples in this work showing coliform bacilli, 1 contained intermediates only, 1 aerobacter only, and 5 intermediates and aerobacter together. Examination of additional samples, however, from the same persons invariably revealed the presence of *Esch. coli*. Further work showed that the fecal flora of individual subjects varied from day to day, and that in feces stored in the cold, *Esch. coli* tended to be replaced by organisms of the intermediate and aerobacter group. The author is so impressed with the variability of the coliform flora in human feces that he regards any attempt to simplify the bacteriology of water and foods by definition of a dominant intestinal type as doomed to failure.—B. H. The article abstracted above includes additional data beyond that given in the previous similar article by the same author in Jour. Bact. and abstracted in J. A. W. W. A. 29: 907 (Jun. '37).—Ed.

**Coliform Intermediates in Human Feces.** LELAND W. PARR. J. Bact. 36: 1 (Jul. '38). "Study has been made of 765 strains of coliform intermediates derived from fresh and stored feces and of additional type strains from other sources. As a working basis for the study of coliform organisms four tests have been utilized, i.e., indol production, methyl-red reaction, Voges-Proskauer reaction, and citrate utilization. All organisms are theoretically to be considered as intermediates which occupy a position between coli and aerogenes possessing one or more characteristics of coli and one or more of aerogenes. In practice we have restricted the intermediates to those so classified by the four reactions used. The complexity of the entire coliform group is recognized. It is believed unwise to dignify the many differences between forms observed with taxonomic recognition. Classification for the entire group should be simple and might well be comprehended in four species of the genus *Bacterium* to include coli, intermediates, aerogenes and cloacae. Whether coliform intermediates are essentially of fecal or non-fecal origin has not been determined. But it is certain that they do occur in stool specimens to such an extent that they must be considered for sanitary purposes as indicators of fecal pollution". [Included among 5 tables is one which contains a valuable summary of differential tests, in the particular combinations used by different workers, for study of coliform intermediates from '24 to date].—Ralph E. Noble.

**Organisms Involved in the Pollution of Water from Long Stored Feces.** LELAND W. PARR. Am. J. Pub. Health 28: 445 (Apr. '38). While not common and probably of little significance in sanitary problems involving communities, it is known that possibility exists for water to be polluted with fresh fecal specimens which contain no typical coliform bacteria. Study of flora of fresh and stored feces important for numerous reasons. One is seeking cause for cases of individual or mass disease, apparently water borne, for which no etiological agent can be named, and occasionally when water in

question, by present standards, appears to be potable. In the 4 yrs. study reported in article, 235 specimens of human feces from 100 persons (both adult and infant) studied in some detail. 38 specimens were stored at 37°C. and studied. More than half of the 235 specimens were stored in the cold room and studies completed on 68 of these. Even after enrichment, 4 of a series of 194 samples (2%) yielded no coliform organisms. Only 14% of all fresh fecal specimens found to contain only *Esch. Coli* in 1 or more of its fermentative varieties. [Dr. Parr, upon recalculating his data, finds that the 9% figure given in the original article should be 14%.] In this 14%, no amount of storage will bring about presence of any other type of coliform organism. Possible for stored fecal specimen to yield "typical" *Esch. Coli* for a very considerable time (359 days in cold). When fecal specimen contains citrate-utilizing coliform bacteria as well as *Esch. Coli* the citrate-utilizers (aerogenes, cloacae, coliform intermediates) multiply more rapidly than coli and eventually replace them. In one test citrate-utilizing bacteria isolated even after 3 yrs., 10 mo., and 2 days cold storage. Among coliform types noted in such long stored fecal specimens are some similar to, if not identified with, slow-lactose fermenters, "coli mutabile", "coli anaerogenes", and even "b. alkalescens", and paracoli. Tests also indicate group named "Bacillus P" of Clemesha may have some sanitary significance under conditions permitting fecal storage in nature.—Harry E. Jordan.

**Influence of Time and Temperature of Incubation on Heat Resistance of *Escherichia Coli*.** PAUL R. ELLIKER AND W. C. FRAZIER. J. Bact. 36: 83 (Jul. '38). Cultures of *Escherichia coli* exhibited a decided increase in heat resistance, as evidenced by percentage survival of cells during heat treatment, while in the initial stationary phase of growth. The increase was more marked in cultures incubated at 28° than at 38.5°C. Time and temperature of incubation of the inoculum decidedly influenced the degree of increase during the initial stationary phase of subculture growth. Heat resistance of all cultures decreased as reproduction commenced and their resistance fell to a minimum during the period of most active reproduction. The resistance then increased again to a second peak as the rate of reproduction decreased and the culture entered the maximum stationary phase of growth. Growth at and above the optimum temperature resulted in cultures whose heat resistance during the maximum stationary phase was distinctly greater than was true of cultures incubated at temperatures below. Possible reasons for the variations between heat resistance of cultures grown at high and low temperatures and the practical significance of results are discussed.—Ralph E. Noble.

**Investigation on the Purification of Water with Respect to Schistosome Cercariae.** G. WITENBERG AND J. YOFFE. Trans. Royal Soc. of Trop. Medicine and Hygiene 31: 5: 549 (Mar. '38). Due to the scarcity and contradictory nature of literature on the subject, authors undertook this study as preliminary to adoption of a surface water source of supply for Tel-Aviv, Palestine. Prior to beginning the experiments, a trip was made to Egypt to obtain snails actively shedding schistosome cercariae [larval stage] and to

study the problem at Egyptian water filtration plants. Egyptian health workers generally believed standard water purification methods were adequate protection against schistosomiasis, this opinion being based largely on epidemiological experience. In making the experiments a suspension of 40-100 per cc. of the cercariae of *S. haematobium* or *S. mansoni* were obtained from the supernatant liquor over snails exposed to sunlight in test tubes. This test material was placed in River Yarkon water and given experimental precipitation, filtration or chlorination. Precipitation with 20, 50 and 100 p.p.m. of alum produced no effect. At 50 and 100 p.p.m. the cercariae seemed to be entrapped in the flocs but freed themselves in  $\frac{1}{2}$  to 1 hr. and were fully active after 24 hrs. Excess lime treatment seemed effective in killing the organisms above pH 11.6, due to the high pH as indicated by parallel experiments with borate and phosphate buffered solutions, but this pH would not normally be reached even with excess lime treatment. When combined with alum treatment, presence of floc which carried organisms to the bottom accelerated the lethal action of high pH, but this treatment was not practical. In experiments with chlorine, hypochlorites and chloramines, raw river water was first clarified with lime and alum and filtered through filter paper. Tables are given showing the progressive effect of increasing concentrations of each of these agents in immobilizing and finally killing the cercariae. In experiments made by siphoning off supernatant chlorine and chloramine solution from the organisms after treatment, it was found that the effect of the chlorine continued and was not reversible. Filtration through 75 cm. of sand with an alum mat on top, was not effective in removing all cercariae, although numbers reduced considerably. Treatments at pressures of 200 atmospheres for 6 hrs. had no effect on their viability.—P. H. E. A.

Additional data from same article:—The lethal effect of chlorine on cercariae depends upon the form of  $\text{Cl}_2$ , its concentration, the  $\text{Cl}_2$  demand of the water containing them and the time exposed. Following table condenses these values (taken from original article):

FORM	PARTS PER MILLION $\text{Cl}_2$		KILLED AFTER EXPOSURE OF	
	Initial	After 10 min.	Hrs.	Min.
Dissolved Gas.....	0.4	0.25	1	15
Dissolved Gas.....	0.8	0.60		30
Sodium Hypochlorite.....	0.4	0.28	1	40
Sodium Hypochlorite.....	1.0	0.42		30
Chloramine.....	0.36	Not stated	1	10
Chloramine.....	0.45	0.22		30

—Ralph E. Noble.

**A Modified Eijkman Medium for Isolation of Escherichia Coli from Sewage.**  
A. A. HAJNA AND C. A. PERRY. Sewage Works J. 10: 261 ('38). Of 565 lactose broth tubes inoculated with sewage, only 54% confirmed for *Esch. coli* against 86.7% from a corresponding series with Eijkman-lactose broth. Addn. of 0.1% Na formate decreased the efficiency of the Eijkman broths.—C. A.

**The Fermentation of Acetyl-Methyl-Carbinol by the Escherichia-Aerobacter Group and its Significance in the Voges-Proskauer Reaction.** R. P. TITTLER. J. Bact. 35: 157 ('38). As previous workers have shown, the Voges-Proskauer reaction should be carried out on cultures not more than two days old; otherwise a certain proportion of positive cultures become negative on further incubation. Whether this is due to fermentation of the acetyl-methyl-carbinol by certain members of the aerogenes group or to its reduction to 2:3-butylene glycol has not so far been clear. The present author, however, brings evidence to show that true fermentation does occur. Out of 90 strains of the aerogenes type, i.e., M. R. —, V. P. +, citrate +, 37 gave a positive V. P. reaction during the first 3 days and a negative one after 5 days. All of these 37 strains were found capable of growing and producing acid in a synthetic medium containing acetyl-methyl-carbinol as the sole source of carbon. The remaining strains were unable to ferment this substance, and gave a persistently positive V. P. reaction in the ordinary glucose broth medium. The 37 strains that fermented acetyl-methyl-carbinol comprised about half of the strains labelled *Aerobacter aerogenes* and *Aerobacter ozytocum*, but none of the strains labelled *Aerobacter cloacae*.—B. H.

**Hydrogen Sulphide Studies. I. Detection of Hydrogen Sulphide in Cultures.** C. A. HUNTER AND H. G. CRECELIUS. J. Bact. 35: 185 ('38). Extensive experiments were made with different media to ascertain most delicate method of detecting production of  $H_2S$  in cultures. Bismuth found to be superior to iron, and media were made up containing bismuth sulfit in which positive reactions were obtained with organisms such as *Bact. paratyphosum* A and Flexner and Shiga dysentery bacilli that show no trace of  $H_2S$  formation in the ordinary peptone iron medium. Difficulties, however, experienced in preparing an absolutely standard medium. Recommended that, in recording ability or inability of a given organism to form  $H_2S$ , the method of testing should always be stated.—B. H.

#### STERILIZATION

**The Policy of Chloramination of Chalk Wells.** ANON. Surveyor. (Br.) 93: 459 (Mar. 25, '38). The water examination committee of the Metropolitan Water Board of London recommends chloramination of all wells pumped direct into supply in spite of long and satisfactory experience to the contrary. Justification of the recommendation is based on the possibility of future contamination of chalk wells, particularly in highly fissured areas. Researches have indicated that isolation of atypical coliform organisms gives early warning of less severe conditions associated with the appearance of *Esch. coli*. Precautionary measures in relation to the presence of typhoid carriers on works have been in force for the past two years. Chloramination fittings are held in readiness at wells which enable application to be made within about 6 to 8 hr.—H. E. Babbitt.

**Preparing and Packaging Liquid Chlorine and Allied Products for Water Plants.** L. L. HEDGEPEETH. J. N. E. W. W. A. 52: 1 (Mar. '38). Demand for chlorine for industry and public health has increased from modest begin-

ning in 1895 to about 424,000 tons in '36. Chlorine made from salt and water by electricity; 100 lbs. NaCl producing 60.7 lbs. Cl, 68.4 lbs. caustic soda, and 1.7 lbs. hydrogen, and requires 82.2 kw. hr. input. In mfg. chlorine underground salt deposits put into 25% brine solution, purified of Ca and Mg, then dissociated in Gibb's Cells using a high current density—0.17 amp. per sq. in. The chlorine gas produced is dried over 93.2%  $H_2SO_4$ ; liquified at 25 lbs. pressure and low temp.; purged of wax-forming impurities in which ferric chloride, hexachlorethane, carbon tetrachloride, bromine and chloroform are found; and finished heavy liquid placed in steel containers of 10, 15, 25, 100 and 150 lbs. capacity. By-products of chlorine mfg. are named, described and uses given. Max. discharge rate of 100 lb. and 150 lb. cylinders at 70°F. is approx. 35 lbs. Cl per 24 hrs. Multiple unit tank car carries 15-1 ton drums and is recommended only where use exceeds 200 lbs. Cl per day. Analysis of some recorded accidents with Cl is given. The least detectable odor of chlorine in air is a conc. of 3.5 p.p.m.; 5.1 p.p.m. is least to cause throat irritation; 30.2 p.p.m. causes coughing; 40-60 p.p.m. is dangerous for 30 min. exposure and a conc. of 1000 p.p.m. is rapidly fatal for short exposure. Chlorine ice does not form at temp. above 49.2°F. If chlorinator tray water warmed for its prevention water should be 50°F. or above but not over 80°F.—*Martin E. Flentje.*

**The Story of the Hooker Cell.** K. E. STUART, T. L. B. LYSTER AND R. L. MURRAY. *Chem. & Met. Eng.* 45: 354 (Jul. '38). Description is given of development of chlorine cells known as Hooker type. Latest type known as type "S" cell. This cell is approx. cubical proportions with top and bottom sections of concrete. Anodes consisting of flat graphite blades are imbedded in lead slab resting on bottom of cell, projecting vertically upward. Cathode of asbestos formed within rectangular frame of steel channel section with rows of parallel cathode fingers projecting inwardly along 2 opposite sides between anodes. Cell has current efficiency from 94 to 95.5%, each cell occupies approx. 70 sq. ft. floor space and produces 373 to 530 lbs. caustic soda and 330 to 470 lbs. chlorine per day. On basis of quality and overall cost per unit of product, cell compares favorably with other diaphragm cells.—*Martin E. Flentje.*

**New Design of the Soviet Chlorinator.** L. A. KUL'SKIĬ. *Mem. Inst. Chem. Tech., Acad. Sci. Ukrain. S. S. R.* 4: 55 ('37). The construction and operation of the latest Soviet chlorinators are described. Outstanding features are the protection of inner parts from action of Cl by a sulfidized Ag coating, and the accelerated mixing of the Cl and water in a mixer of special design. Chlorinators have been produced for com. use since '37.—*C. A.*

**Control of Chlorine Passing Through the Chlorinator Capillaries.** L. A. KUL'SKIĬ, I. P. MALYUSHITS'KIĬ AND G. M. MITILINO. *Mem. Inst. Chem. Tech., Acad. Sci. Ukrain. S. S. R.* 4: 75 ('37). The speed of Cl outflow through capillaries of 0.2, 0.4, 0.6 and 0.8 mm. diam. and under pressures of 0.5-2.0 kg./sq. cm. was proportional to area of cross section. Within residual pressure limits of 1.02-1.32 kg./sq. cm. the outflow is dependent chiefly upon gas

density. On the basis of expts. tables of Cl feeding for various capillaries were computed.—C. A.

**Germicidal Properties of Chlorine Compounds.** DAVID CHARLTON AND MAX LEVINE. Iowa Eng. Expt. Sta., Bull. 132, 60 pp. ('37). Critical review of 73 literature citations shows marked lack of agreement in regard to relative germicidal efficiencies of different Cl compds. and mechanism of their germicidal action. Bacterial spores were very suitable for studying factors affecting germicidal properties. In expts. with chloramine-T, it was found that doubling concn. reduced killing time approx.  $\frac{1}{2}$  and that increasing temp. 10°C. reduced killing time 71.5–82%. Changes in pH value had very marked effect on germicidal properties, more acid reactions being more germicidal. Hypochlorites were more markedly affected by changes in pH temp. and Cl. concn. than was case with chloramine-T. Chloramine solns. were not influenced as greatly by changes in reaction (pH) as hypochlorites or chloramine-T. For given Cl concn., chloramine-T exhibited weakest germicidal action; in solns. more alk. than pH 9.5–10.0, monochloramine was more germicidal than hypochlorites; in less alk. solns., hypochlorites were more germicidal. With hypochlorites, concn. of hypochlorous acid was the significant factor in germicidal action: with chloramine and chloramine-T, however, hypochlorous acid did not play significant role. Disinfecting action for all compds. is assocd. with presence of a pos. Cl atom.—R. E. Thompson.

**The Action of Chlorine on Phenol in Alkaline Solution and the Possibility of the Production of Chloraniline.** J. CHULKOV, V. PARINI AND STAROSSELETZ. J. Ind. org. Chem. (U. S. S. R.), 3: 97 ('37); Chem. Zbl. 1: 1419 ('38). In connection with the problem of the treatment and utilization of waste waters containing phenol, aqueous solutions containing phenol and sodium hydroxide were treated with chlorine gas at room temperature. When 15 mols of sodium hydroxide and 3 mols of chlorine are added to 1 mol of phenol a mixture of 0-chlorphenol, and 2,4- and 2,6-dichlorphenols is produced. With double these quantities of alkali and chlorine 2,4,6-trichlorbenzene is formed. If the proportion of chlorine is further increased the amount of trichlorbenzene produced decreases; on acidifying the mass carbon dioxide is produced and chloroform can also be detected. When 20 mols of chlorine are added to the alkaline solution the phenol is completely oxidized to carbon dioxide. From the precipitate which is formed on acidifying the solution to which 6 mols of chlorine have been added, chloraniline may be produced by adding nitric acid in the presence of hydrochloric acid.—W. P. R.

**Experimental Bacteriological Research on the Electro-Katadyn Method for Disinfection of Drinking and Bathing Water.** SILVIO HOFFMANN. Monats-bulletin (Swiss). 18: 129 (Jun. '38). Experimental work substantiating previous experiences of other workers is reported. Disinfection with process found dependent on conc. and kind of bacteria present, conc. of silver, and presence of certain hindering substances as hydrogen sulfide, iron, chloride, albumen, urea and ammonia.—Martin E. Flentje.

